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THE PRESERVATION OF TIMBER.

APPENDIX TO THE REPORT OF THE COMMITTEE.

APPENDIX No. 2.*

KYANIZING.

LETTER FROM J. B. FRANCIS, PAST PRESIDENT, AM. SOC. C. E.

O. CHANUTE, Esq.,

Chairman of Committee of the Am. Soc. of Civil Engrs. on the Preservation of Timber.

DEAR SIR,—In reply to your inquiry as to my experience in the preservation of timber, I have to say, that in the year 1848, as Chief Engineer of the Proprietors of the Locks and Canals on Merrimack River, who control and manage the water power furnished by that river at Lowell, Massachusetts, finding the need of some means of preventing the rapid decay of the numerous wooden bridges and other works maintained by them, I recommended the adoption of Kyanizing, and the

*Appendix No. 1 is a paper on The Preservation of Forests, by F. Collingwood, M. Am. Soc. C. E., and is published separately.

necessary works were erected. The process was patented in England by John Howard Kyan, March 31st, 1832, and soon after in the United States. It consists in impregnating the wood with a solution of bi-chloride of mercury, commonly called corrosive sublimate. Two wooden tanks were provided, each about fifty feet long, seven and a half feet wide, and four feet deep. In these the timber to be prepared is placed, the several layers being separated by laths, and the spaces filled with the solution, consisting of corrosive sublimate, one part, and water, ninety-nine parts. The timber is kept immersed a length of time depending on its least thickness, one day being allowed for each inch in thickness, and one day in addition, whatever the thickness; thus, for a six-inch timber seven days' immersion is allowed.

In 1850 we were induced to substitute Burnettizing for Kyanizing, it being said to be equally effective, much cheaper, and more expeditious. The two processes are alike, except that in Burnettizing chloride of zinc is the antiseptic. Corrosive sublimate, the antiseptic in Kyanizing, attacks iron, which interferes with the latter process being carried on in closed tanks from which the air is exhausted, and the solution injected under high pressure. Chloride of zinc is free from this objection. Burnettizing was carried on at Lowell for about twelve years by the expeditious process of exhaustion and pressure.

In 1862 we resumed Kyanizing, our experience of fourteen years having indicated that it was a much more effective preservative for our purposes than Burnettizing.

In 1849 the Pawtucket Street Bridge over the Northern Canal was built. It is a stringer bridge, about 120 feet long and 30 feet wide, supported by two piers and two abutments. The timber is northern white pine, and is all Kyanized. No repairs were made upon it, except the surface planking, until April, 1882, when three of the stringers were found to be so much decayed as to require renewal, and the lower ends of some of the braces, which came in contact with masonry or rock, were cut off and replaced. Some of the remainder of the timber had signs of decay, but is considered good for some years to come.

In 1850 the Proprietors of Locks and Canals built a picket fence, eight feet high and about six hundred and seventy feet long, of Kyanized spruce, around a small reservoir. It has been whitewashed from time to time, the last time about seven years ago, and it is now nearly bare. The posts are about six by eight inches, with three rails. I made an examination of the fence on the 11th inst., and found very little sign of decay above the surface of the ground, and this part of the fence is serviceable for many years longer. Below the surface of the ground, which is a dry gravel, all the posts are decayed more or less; about one-half of them are rotted off, or nearly so, at the surface of the ground, and the opportunity of this examination has been taken to batten them, with two and a half inch Kyanized spruce plank, six and a half feet long,

which it is expected will extend the duration of this part of the fence for many years. The remainder of the posts, although, as I have said, they are decayed, more or less, are considered serviceable for some time longer, without battening.

In 1862, when Kyanizing was resumed, for the purpose of obtaining some definite information as to its effects on different woods, specimens of twelve kinds growing in the valley of the Merrimack were obtained and prepared in the usual manner. The following is a schedule of the specimens, which were collected and prepared as above, in the summer and fall of 1862:

No. 1,	Old growth white pine,	18 feet	long,	9 x 9	inches.
" 2,	Sapling white pine,	"	"	"	"
" 3,	Northern hard pine,	"	"	"	"
" 4,	Spruce,	"	"	"	"
" 5,	Hemlock,	"	"	"	"
" 6,	Beech,	"	"	"	"
" 7,	Black birch,	"	"	"	"
" 8,	Yellow birch,	"	"	"	"
" 9,	Rock maple,	"	"	"	"
" 10,	White maple,	"	"	"	"
" 11,	Brown ash,	"	"	"	"
" 12,	Poplar, cottonwood,	"	"	7 x 7	inches.

The specimens, after being numbered as above, were cut in two, and one-half of each was Kyanized, and the other half retained in its natural state.

In the following spring, April 29th, 1863, they were set out in the ground as posts, in two rows, about four feet of their length in the ground and about five feet out, where they still remain. The specimens have been fully exposed to the weather, the unprepared row being about two feet from the northwest side of a building, and the Kyanized row about six inches in front of them, all being about nine inches apart in the row. The soil is a coarse gravel, rather binding, but containing no clay, and is thoroughly drained by the cellar of the neighboring building, the walls of which are laid without mortar.

On the 13th inst. they were examined with reference to their state of preservation. The unprepared specimens, both above and below the surface of the ground, are very much decayed, and their forms are retained only by being boxed up on all sides with boards. The Kyanized specimens, although nearly all of them, in the parts below the surface of the ground, are somewhat decayed, retain their forms perfectly, and have the ring of sound timber when struck. There are differences in the amount of decay in different specimens. In all the specimens it appears to be confined to the parts below the surface of the ground and to within

an inch of the surface of the wood. The hemlock shows no signs of decay; the other specimens all show some signs of decay, and by inspection appear to have been preserved in the following order: Black birch, brown ash, beech, white maple, and rock maple.

The three specimens of pine, the spruce, and yellow birch follow; but are so nearly equally preserved that they could not be graded.

The Kyanized specimen of beech has some season cracks which contain fungus, from which similar cracks in the other specimens are free. The cottonwood is the most decayed, apparently extending to about an inch from the surface, but it is still firm and serviceable as a post, and the part above ground shows no signs of decay; a sixteenth of an inch below the surface the wood is bright, and much harder than new wood. The unprepared specimen is decayed to an extent resembling black soil.*

Cottonwood does not grow naturally in the valley of the Merrimack; our specimens were from a tree planted on the bank of a canal. As is well known, it grows very rapidly and is propagated with facility from cuttings. My experience with it is very limited, but as far as it goes, it indicates that, in localities suited to its growth, it might be cultivated with advantage as a timber tree and be made as durable as most other woods by the Kyanizing process.

The cost of Kyanizing depends mainly on the price of corrosive sublimate. This has been latterly much reduced. In 1848 it was $1.25 per pound; the present price is from 50 to 55 cents per pound, depending on the cost of quicksilver. The average quantity used at Lowell is about five pounds per thousand feet, board measure, or 0.06 pounds per cubic foot, making the cost of the corrosive sublimate not exceeding $2.75 per thousand feet, board measure, or $3\frac{3}{10}$ cents per cubic foot. This is deduced from the amount used during several years, and is of course an average. There are considerable variations in the amount of corrosive sublimate taken up by the Lowell method, depending on quality, size and state of dryness of the timber. The other principal items that enter into the cost are labor and interest on cost of the plant. These will vary much in amount, depending on the extent and regularity of the operations.

The patent has expired long since, and there is of course no royalty to be paid.

If any further information on the subject, in my power, is desired, I shall be happy to communicate it.

Very truly yours,

JAMES B. FRANCIS.

LOWELL, MASS., July 16th, 1885.

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* Characteristic specimens cut from the above were shown at the National Exposition of Railway Appliances, held at Chicago, in May and June, 1883, and are now in the Civil Engineers' Museum of the University of Illinois, at Champaign, Ill.

APPENDIX No. 3.

Kyanizing on the Eastern Railroad.

By H. Bissell, M. Am. Soc. C. E.

O. Chanute,
Chairman Com. Preservation of Timber, Am. Soc. C. Engrs.

Sir,—The following is a condensed statement of the Eastern Railroad Co.'s experiments for wood preserving:

About 1846 arrangements were made for Kyanizing track timber. The apparatus consisted of an iron cylinder 40 feet long, 4 feet in diameter; two tanks, each of same capacity as cylinder, one above and one below the cylinder; a steam boiler, with pumps, etc. The cylinder was filled with timber, closed and filled with steam, then allowed to stand for 20 minutes. This was supposed to take the sap out of the wood. The cylinder was then filled with the liquor from the upper tank, the liquor pumped in to a pressure of 150 lbs. per square inch. This was allowed to stand for 20 minutes, sometimes longer, the liquor then drawn off into the lower tank, and the timber removed. The solution used consisted of corrosive sublimate dissolved in hot water in the proportion of 1 pound to 30 gallons. There is no record of how much corrosive sublimate was absorbed per 1 000 ft. The boiler and tanks were protected from the action of the liquor by applying hot asphaltum varnish. The corrosive sublimate cost $1.50 per lb. The process was abandoned after a few years' trial, partly on account of cost, which averaged 7½ cents per cubic foot, and partly on account of changing from the method of laying rails on longitudinal timbers to using ties as at present. The timber treated was spruce and oak. Reports of results are vague and various. Nearly all admit that the process was beneficial, and it is claimed that some spruce timber lasted twenty years.

In 1879-80 works were erected at Portsmouth with the intention of using the Bethell process of creosoting. A building was erected containing two cylinders, each 6½ feet in diameter, one 66 and one 84 feet long, steam engine, air and liquor pumps and fixtures, the whole costing more than $12 000. The works were burned in April, 1880, when ready for starting. Owing to the scarcity and very high price of creosote oil, it was decided not to rebuild works for creosoting, but to try Kyanizing instead.

Four tanks, each 60 feet long, 9½ feet wide and 6 feet deep, were built of granite laid in cement, coated on the inside with coal tar applied hot. These tanks are covered by a frame building. A large tank of boiler iron, which was left from the wreck of the creosoting works, is used as a reservoir tank. For making steam, an old locomotive boiler is used. The tanks are filled with ties or timber, which is kept from floating by oak bars across the top of the tank. A solution of corrosive

sublimate is then pumped in from another tank, which is ready to be emptied, or from the reservoir tank, till the timber is covered. When the tank is filled, the liquor is warmed by blowing steam into it. The liquor used is corrosive sublimate, dissolved in water, in the proportion of 1 pound to 99 pounds. The corrosive sublimate is dissolved in a large cask of boiling water. The solution in this cask, which is very strong, is added to the liquor in the tanks as required to keep it of the requisite strength, which is determined with a hydrometer. The thickness of the timber determines the duration of the soaking; ties 6 inches thick require one week, twelve-inch timber, two weeks. When a tank is to be emptied, the liquor is pumped out before the timber is removed. The iron tank is given an occasional coat of hot coal tar, and the liquor has no effect on the iron. The pipes that come in contact with the liquor are of wood or rubber. The man who has the care of the work has in a few cases been nauseated for a short time by inhaling the steam while dissolving the corrosive sublimate, but by using proper care there was no necessity for this. The men handling the timber have never experienced any injury, and they are often needlessly careless.

Kyanizing was commenced in April, 1881. To March 1st, 1883, 388 000 cubic feet of ties, planks and timber have been treated, seven-eighths of the amount being ties. The average amount of corrosive sublimate absorbed has been $2\frac{6}{10}$ pounds per 100 cubic feet. The amount varies greatly, wood of rapid growth, with a large proportion of sap, taking much more than wood of slow growth. Seasoned timber not only absorbs more liquor, but leaves liquor in tank weaker than wet or green timber. No tests have been made to determine these differences. The average cost of the corrosive sublimate has been 51 cents per pound. The cost of labor varies greatly, as sometimes timber is taken directly from the cars to the tanks when first received; oftener it must be rehandled. The average cost for material, labor, fuel and interest on money invested in works and material is $3 per 100 cubic feet. The process was begun too recently to make any statement as to durability. The wood is contracted and made tougher, and is worked with more difficulty than before it is Kyanized.

Truly yours,

H. Bissell, M. M. W. *Eastern R. R.*

Salem, Mass., March 13th, 1883.

APPENDIX No. 4.

BURNETTIZING ON CENTRAL VERMONT RAILROAD.

ST. ALBANS, VT., April 28th, 1882.

O. CHANUTE, Esq.,

127 *East Twenty-third street, New York, N. Y.*

DEAR SIR,—In reply to your favor of the 25th instant, I would say that in 1856 this road erected works for the purpose of extracting sap from wood and of infusing chemicals for the purpose of preservation. It was in use some four years, but it was so much work to get through with such large quantities of timber as are used upon a railroad that it was thought best to abandon the work; therefore, the boiler and fixtures were removed and sold, and nothing more was thought of the "Burnettizing" process until some three years since, when an old side track was removed, which had not been in use for several years, and which was nearly covered with earth and grass; still the hemlock ties were then found to be nearly sound, having laid there for nearly 25 years. I did not keep watch of other prepared timber put in at that early time, and as repairs are constantly going on upon a railroad, I am unable to say whether there are any other similar cases upon our line or not, but there is no doubt that the preservation of these ties was due to the process above named.

The reasons for abandoning the Burnettizing works upon this road would seem to be that the officers in charge at that time lost faith in the theory, and as it was an experiment, they did not learn of its value until recently discovered in the manner referred to. There is no question, in my opinion, regarding the value of the process.

Yours very truly,

J. W. HOBART, *Gen. Supt.*

APPENDIX No. 5.

BURNETTIZING ON THE BOSTON AND ALBANY RAILROAD.

12 WEST STREET, BOSTON, MASS.,
September 26th, 1882.

O. CHANUTE, Esq.,

Chairman of Committee on Preservation of Timber.

DEAR SIR,—In reply to your circular and inquiries, I beg to give you the following statement:

In 1860 I constructed an iron girder deck bridge, to carry the tracks of the Boston and Worcester Railroad (now Boston and Albany) over the highway known as "North Beacon street," in the town of Brighton, now a part of Boston, and about 1 500 feet west of Brighton Station.

The bridge is nearly a hundred feet long, and was covered with Bur-

nettized green spruce ties, sawed 10 inches by 10 inches, and laid 10 inches apart.

I am informed by the man who had charge of the repairs that these ties had become badly checked, so as to be unable to hold spikes, after about nine years' use. They were renewed in 1869 or 1870 by white pine ties, in their natural state.

This second set of ties lasted only till 1875, *i. e.*, five or six years. They were then found somewhat decayed, and failed to hold the spikes, and were renewed by chestnut ties without any treatment. This third set lasted till the present season, when they were again renewed by untreated chestnut, that timber having served for a period of seven years.

I have no information as to the quantity of zinc chloride injected in the first set of ties. The work was done upon green timber, by first withdrawing the sap in an exhausted boiler, and afterward applying the solution of chloride, under a pressure of 300 pounds per square inch. The parties who did this have since discontinued the business for lack of patronage.

The traffic over this bridge has been large from the first, being now between fifty and seventy-five trains per day in each direction.

I am told that the burnettized spruce ties first used failed in a similar manner to untreated spruce, though only after a period of some nine years, while the latter will fail in such a place with four or five years' exposure. The failure is by cracking open and admitting air and water, after which the fiber depreciates rapidly.

My observation has led me to suppose that Burnettizing is of more avail where timber is covered with earth than when exposed to sun and air. Such exposure cracks and opens the timber just as soon as if it had not been Burnettized, and it then depreciates more rapidly than if not so checked.

If Burnettized spruce were used for ties in ordinary ballast, spaced as usual and subjected to a traffic as great as in the instance referred to, it would wear out long before it would suffer from decay. That is to say, the rails would crush into the wood and cut the tie half off, in much less than nine years.

This was prevented on the bridge referred to by the large bearing surface afforded by the unusual number of ties per rail, which were supplied for another reason, viz., to make a bridge floor strong enough to carry derailed wheels with impunity, a practice which I have followed on all railroad bridges for the past twenty-five years.

The process of Burnettizing, so far as my observation goes, does not affect the hardness of the timber; so that it is just about as well adapted to resist a crushing force, whether Burnettized or not. It does, however, undoubtedly put off decay; so that in all cases where timber is likely to fail through decay, and not by crushing or wearing out, the process will be of advantage, depending, of course, on local prices.

As far as I can learn, the present management on this railroad prefers to use chestnut without treatment, because under the existing circumstances this timber is cheaper than Burnettized spruce, and will resist decay till worn out or crushed, a period of some seven years in this case. But for roads of lighter traffic, or where the ability to resist decay would be of more consequence, the use of Burnettized or creosoted spruce would soon increase, if there were a larger supply of spruce in the market.

There is no kind of timber, suitable to hold spikes, in this part of the country, so cheap as spruce and hemlock, but it seems that this is not cheap enough, or rather that the chestnut is too cheap to make it worth while to Burnettize the spruce.

Many railroad companies in New England, especially on the slopes of the Connecticut Valley, grow their ties on their own lands.

Chestnut is found to produce a new crop once in fifteen to twenty years, by sprouting from the old stumps, a quality possessed by very few other trees.

The railroads along the seaboard of New England use swamp cedar ties. It is a soft, corky wood, quite unsuitable for a heavy traffic, but serves tolerably for passenger business, where no sharp curves are required. It generally fails by wearing out, *i. e.*, becomes unable to hold spikes, which loosen quickly, rather than failing by decay, except on roads with very light traffic.

I have used a limited quantity of Burnettized spruce for fencing rails and boards, and have found that it endures for eight or ten years, and is after that period apparently no further depreciated than untreated spruce becomes in about half that time. I have no means of learning what quantity of the zinc chloride was injected per foot.

As we are fast approaching a time when good timber will be a scarce article, my opinion is that there will be a growing demand for such preparations as are found best adapted to prolong its life, and that it will be an easier matter to so treat timber as to increase its power to resist decay than to strengthen its fiber against wear, while the latter item is in many cases quite as important as the former. The most efficient remedy for this trouble is undoubtedly to be found in providing more bearing surface for the loads. This may be done where timber is comparatively plenty by supplying a greater quantity of timber per mile, or in other words by applying the ties at more frequent intervals.

Where timber is more scarce the bearing surface may be increased by applying broad plates of iron at every tie, as is done in England with the reversible rails, or by more simple devices adapted to the flat-bottomed rail, by blocks of hard wood or iron plates. Such plates would probably last much longer than the timber, and serve for several sets of ties in succession. Moreover, they contribute much lateral support to the spikes, if spike holes are provided in them.

Yours very truly, EDWD. S. PHILBRICK.

APPENDIX No. 6.

German Experience with Preserved Railroad Ties.

[Translated for the *Railroad Gazette* from an article in the *Organ fur die Fortschritte des Eisenbahnwesens* by Privy Councillor Funk, of the Cologne and Minden Railroad.]

With the increase in the employment of iron as a material for the superstructure of the railroad in modern times, it might appear that any discussion as to the durability of wooden railroad ties and methods of increasing it had lost much of its interest. But when we come to consider that even where the results of experiments with the iron superstructure have been most successful, the roads will still be constrained to employ wooden ties for a long series of years; that more than half of the sixty millions wooden railroad ties that have been laid on the railroads of Germany and Austro-Hungary have been subjected to no treatment to prolong their life; and that millions of these rapidly deteriorating ties are annually replaced by others equally devoid of any means of preservation, while at the same time positive practical experience among the members of the German Railroad Union, extending over a period of thirty years, shows that several millions may be annually saved in the renewals of ties alone, we should have sufficient excuse for the occupation of valuable space in such a discussion. To these reasons must be added the urgent necessity existing in modern times for the utmost economy in railroad matters, and that those roads doing the least business will be most benefited by it, as in their cases the destruction of ties is caused by rotting more than mechanical wear. I am still further impressed with the utility of this subject by the results of my thirty-six years' experience in the construction and maintenance of the Royal Hanoverian and the Cologne and Minden Railroads. On both of those roads the importance of finding some method of prolonging the life of ties has been fully recognized, and since 1847 on one and 1849 on the other road, for periods of 32 and 30 years respectively, such methods of adding to the durability of the ties have been extensively employed. Then again, at the technical conventions of the Railroad Union, held in 1865 in Dresden, and in 1878 in Stuttgart, where this was one of the questions submitted for discussion, I was appointed reporter, and for the last few years I have had frequent inquiries from different parties respecting my experience in this matter on the Hanoverian and the Cologne and Minden Railroads, with a view to the introduction on other roads of the methods of impregnation practiced here.

We cannot be expected here to take into consideration, or even express an opinion on, the many different propositions and experiments

that have been made with a view to increasing the durability of wood; we shall confine ourselves rather to a discussion of such as have been most successful. But in order to comprehend and obtain a correct view of them, it is necessary to precede their description with a few general remarks.

I—General Remarks.

Wood, as is probably known to our readers, is made up of the woody fibers proper (cellulose) and the juices or sap that fill the interstices between them. The first are almost alike in composition in all woods, the chemical constituents being carbon 52.4 per cent., oxygen 41.9 per cent., hydrogen 5.7 per cent.; the sap differs in each kind of wood. The sap of oak is particularly rich in tannin, that of beech in vegetable albumen, and that of the different species of pine in resin. In all of them we find, in addition to the above, gum, vegetable glue, gallic acid, sugar, etc., in solution.

The pure wood-fiber is not particularly liable to decomposition; this is generally caused by the sap. This substance shows, like all organic bodies, a strong tendency to decompose, *i. e.*, to resolve itself into such combinations as are less liable to attack by putrefaction.

This latter stage is the result of putrefactive fermentation, induced by the oxygen of the atmosphere, and, when the sap is in this condition, the wood-fibers are affected by it.

The sap of felled wood goes over into putrefactive fermentation only under the following conditions:

1. When the access of air is permitted.
2. When the wood is in a damp state.
3. Under the influence of a moderate temperature, ranging, say, from 328° to 122° F.

If both air and oxygen are excluded from the wood, putrefactive fermentation cannot set in, and on this principle is founded the preservation of food in air-tight cans, and the almost endless durability of wood under water. The fact of moisture being requisite to a state of putrefaction is proved by the preservation of many substances by drying and kilning, and the great durability of the thoroughly dried wood in old buildings that are protected from any moisture. In the same manner we prove that warmth is necessary to putrefaction, by the discovery in the Siberian ice-fields of perfectly preserved mammoths, while, on the other hand, we know that at a temperature above 122° we commence the kiln-drying process.

We may, therefore, conclude that on the putrefactive fermentation of the sap, consequent on the presence of these three factors, depends the rotting of the wood, and the means of increasing its durability are consequently directed chiefly toward their frustration.

II—Methods of Increasing the Durability of Wood as now Practiced.

Firstly.—The sap must, as far as possible, be removed from the wood, and this expulsion, or rather diminution, of sap present, is effected either—

a. By felling in winter time, when there is least sap in the trees.

b. By girdling and barking the standing trees, as practiced in some districts.

c. By drying in the open air or in heated rooms.

d. By extraction by means of water.

e. By steaming in a closed vessel.

Secondly.—Such sap as may be left in the wood must be protected from putrefaction by preventing an occurrence of the conditions we have described above. This may be effected by—

a. Exclusion of air and moisture by painting with oil, tar, etc., or by nailing tin or felt paper over every part where the cross grain is exposed.

b. Removal of the moisture from wood by charring, which at the same time coagulates the albuminoids in the wood and forms a charred outer surface, through which substances favorable to putrefaction from the outside find great difficulty in penetrating.

c. Through the infiltration into the wood of, or its impregnation with, antiseptic fluids, by means of which putrefactive fermentation will be prevented, no matter how favorable to such a process the condition of the wood may be.

III—Modern Methods of Preserving Wood.

The latest methods of wood preserving are founded on infiltration or impregnation by antiseptics, and among those best known we reckon: (1) salts, green vitriol (sulphate of iron), blue vitriol (sulphate of copper), corrosive sublimate (bi-chloride of mercury), chloride of zinc, common salt (chloride of sodium), and potash (carbonate of potassa); in addition to these, we find used certain volatile oils, resins, aromatic substances, tannic acid, and, lastly, the product of the dry distillation of vegetable substances, containing principally pyroligneous acid and creosote.

The actual effects of these different substances are still comparatively unknown. Some are supposed by coagulating the albumen to secure it against putrefaction; others combine with the vegetable glue and form insoluble compounds incapable of fermentation; while others appear to prevent putrefactive fermentation by their simple presence.

Of the many different experiments that have been made with the substances just mentioned, either separate or combined, with a view to increasing the durability of wood, after long years of experience only

four have acquired any practical importance. These are the impregnation of wood with—

1. Sulphate of copper (blue vitriol).
2. Corrosive sublimate.
3. Chloride of zinc.
4. Creosote.

Experiments with the other methods have been quite abandoned, partly because the results were not satisfactory, and partly because the same effects were obtainable at less expense. The Boucherie process, so much used in France, which consisted of infiltration of the antiseptic fluid, generally sulphate of copper, into the wood of the tree while standing, thus forcing out the sap, has found few friends in Germany and Austria, and is now entirely abandoned there. The process was rendered still more difficult by the fact of its being only applicable at a certain time and in a particular place; it was expensive, and the results not so favorable as with impregnation.

The system of soaking the wood in a warm or cold antiseptic solution, or even boiling therein, has in like manner proved unsatisfactory, compared with impregnation, because the solution cannot permeate the wood thoroughly.

We may refer also to the process of steeping in corrosive sublimate solution, as practiced almost exclusively in England from 1838 until lately. It is now almost entirely given up. Nor has it been widely adopted on the Continent, although effective, for the reason that not only is it a very costly process, but it is likewise very injurious to the health of those who have to conduct it.

The impregnation of wood with the three above-mentioned and most used substances, sulphate of copper, chloride of zinc and creosote, is now accomplished universally in a closed tank, under a powerful pressure of from 7 to 10 atmospheres, which insures the greatest possible penetration of the antiseptic fluid into the pores of the wood. To aid and facilitate this penetration, and also to reduce the sap as much as possible, the wood is either previously highly dried, in creosoting, or thoroughly steamed in the impregnating tank, where chloride of zinc or sulphate of copper is employed. In the latter case the air is pumped out of the tank, as far as is possible, and the dissolved sap is thereby drawn out from the wood, to be drawn off by a proper discharge tap. If the impregnating fluid is then allowed to run into the tank it penetrates very readily, and under a powerful pressure, kept up for several hours, will permeate the wood from end to end.*

*Dr. Wöhler, of Göttingen, undertook the analysis of some oak ties that had been impregnated with chloride of zinc on the Hanoverian railroads under a pressure of eight atmospheres. In the innermost layer of the wood he found the chloride. This proves that if the solution had reached the innermost portion of the timber by simple impregnation the saturation would have been still more complete had the process been preceded by steaming.

Just as the process of infiltration with antiseptics was first invented and practiced by a Frenchman, Boucherie, so it was later with the process of impregnation, which was discovered by Breant in 1831 and patented by him in 1838, but he forced the solution into the wood by simple atmospheric pressure instead of putting on a direct mechanical pressure as now practiced.

The Englishmen, Bethell and Payen, secured a patent in 1840 on the process of impregnating wood with oil of tar and other bituminous substances containing creosote, by the application of a powerful pressure directly upon the impregnating fluid, after the wood has been, as far as possible, freed from air. The Bethell process of creosoting consists, consequently, of the following operations :

1. Thorough drying or steaming.

2. Removal of the air from the wood by the exhaustion of the impregnating tank.

3. Heating the liquid to a temperature 100° to 125° F. before admitting it to the tank, in order to render it sufficiently fluid.

4. Admitting the fluid and driving it into the wood by a pressure of from 7 to 10 atmospheres, maintained for 6 or 7 hours.

Impregnation with chloride of zinc was first proposed in 1838 by W. Burnett, in England, and there patented by him. At first, the process was confined to a simple steeping in the solution for 21 days, but this was ultimately abandoned for impregnation under pressure in a closed tank. The process met with little favor at first, better results being attributed to the use of sulphate of copper (blue vitriol). As soon, however, as it came to be considered that while the use of blue vitriol required costly copper tanks, iron would do for the chloride, and that in addition the latter was by far the cheaper of the two, it gradually grew into popularity. From England the process was carried to Bremen by the shipbuilder Wendt in 1846, and at first the telegraph posts of the line between Bremen and Bremerhaven were treated with the chloride. In 1847, as a further experiment, some 6 000 ties of the Hanover and Bremen Railroad, and soon afterward the timbers of the bridge over the Elbe, at Wittenberg, were subjected to the process.

Since 1851 chloride of zinc has been used exclusively on the Hanoverian railroads, and from a little later date on the Brunswick lines; and so it gradually spread over Germany, until at the present time in Austria and Germany it is employed by twenty different railroad managements.

The process consists in the following operations:

1. Steaming the ties from one to three hours, at a steam pressure of three to four atmospheres, for the extraction of the sap, assisted by running off the extracted sap and condensed steam at intervals of thirty minutes.

2. The air in the tank is gradually exhausted during one to three hours, until a vacuum of 20 to 24 inches mercurial column has been

obtained, this to insure a more complete extraction of the sap from the wood and a more thorough penetration of the impregnating fluid.

3. Admission of the impregnating fluid into the tank, and absorption by and forcing into the wood at a pressure of seven to ten atmospheres, maintained for three or four hours.

The impregnating fluid consists of chloride of zinc (metallic zinc dissolved in muriatic acid), containing from 28 to 30 per cent. of zinc (specific gravity 1.80 to 1.85), and diluted with thirty to sixty parts by volume of water to one of chloride of zinc. This dilution, sixty volumes of water, is recommended by Burnett, and experiments have proved that greater success attends the use of weak solutions than where the stronger are used. In Germany the chloride is generally dissolved in fifty times its volume of water.

Blue vitriol (sulphate of copper) is still used to a considerable extent in Germany for the impregnation of ties. In most cases this is not effected under pressure after a previous steaming and extraction of the sap from the wood, but only by steeping the ties or boiling them in the impregnating fluid. This may account for the very various, and in part very unfavorable, opinions expressed respecting impregnation with blue vitriol, which must be attributed more to the methods of impregnation than to the substance employed.

IV—Cost of Impregnation.

In considering the question, whether it is more advantageous to impregnate the ties before using them, or to use them in an unprepared condition, the cost of impregnation is of decisive importance, as the increase of durability attained by impregnation must bear proper proportion to the increased cost of the ties that have been subjected to this process. The expenses attached to impregnation must include, not only the cost of material and labor, but the interest payable and the addition to the sinking fund necessitated by the cost of erecting the impregnating works, and also the extra expense of transportation. There is no doubt that the outlay attached to the establishment of works for impregnating under pressure has frequently prevented railroad administrations from using this process.

Materials.—The materials employed vary considerably in price, and their cost depends also, to a great extent, on the amount of water that is used in making the solution of mineral salt. Chloride of zinc containing 28 per cent. of the metal costs from $1.55 to $2.21 per 100 lbs. The degree of dilution recommended by Burnett is 1 part by volume of the chloride to 60 parts of water. This, or a similar proportion, appears to be more commendable than the strong solution of 1 in 30 in use on some lines—the Brunswick Grand Ducal Railroad, for instance. When we impregnate under a pressure of 7 to 8 atmospheres, we find that oak ties containing 3.5 cubic feet of wood absorb an average of 0.35 cubic

feet; beech ties of like size, 0.68 cubic feet; and pine ties, 0.70 cubic feet of the impregnating fluid.

Blue vitriol costs $7.70 to $10 per 100 pounds, and, like the chloride, is used in solutions of varied strength, but in most cases with sixty parts by weight of water. The quantity absorbed would, with suitable wood and an equal pressure, be about the same as is given for chloride of zinc; but we must take into account that many roads using the blue vitriol only steep or boil their ties; the remainder employ almost exclusively a low pressure of one and a half atmospheres, equal to that naturally exercised by a column of water 39 to 40 feet in height.

Creosote obtained from Bethell, of London, costs $1.55 to $1.77; that manufactured in Germany by Bronner, of Frankfort-on-the-Main, $1.09 to $1.32 per 100 pounds. This creosote consists chiefly of coal-gas tar, which is distilled a second time, to render it more fluid under the influence of heat, by removing all the small coaly particles. Bethell's preparation is supposed to contain from 1 to 2 per cent. of creosote, but careful analysis showed that for the most part it contained no trace of that substance, and Bethell explained later that its presence was not essential to success.

The process still retains the name of creosoting, although of late the high-priced material imported from England has not been used.

With the cost of material must be reckoned the outlay for coal, oil, red lead, etc., used for the engines and boilers employed in impregnating, the prices of which are well known. The proportion per tie will depend on whether the engine serves one or more impregnating tanks.

The cost of labor is made up chiefly of the expense of handling the ties at the tanks and running the engine. The outlay for this purpose will depend on the perfection of the labor-saving contrivances. The most economical arrangement as yet devised is that in which the ties are loaded cylindrically on iron cars that can be run into the tank and out again on a track. This is effected by having one end of the tank removable and fastened by screw-bolts. The expense of interest and sinking funds for the capital invested depends on the amount of such capital required, and also on the number of ties that require impregnating. The more rapidly the process of impregnation is carried on, and the greater the number of ties to be impregnated, the less will be the proportion of expense to each tie.

The total cost of establishing an old-fashioned impregnating establishment for chloride of zinc on the Hanoverian railroads, with two impregnating tanks of 32 feet 8 inches in length and nearly 6 feet diameter, constructed to stand a pressure of eight atmospheres, with the building, steam engine, air and force pumps, reservoirs and cars to run into the tanks, but without the site or side tracks, was about $8 000. An earlier constructed apparatus, at the Minden station, built for creosoting, but now used for chloride of zinc, cost $19 600. It has been in

constant use since 1849 without requiring any considerable repairs, and in 1874 was removed to the neighboring depot of Porta, on the Weser. The impregnating apparatus at Brunswick, with two tanks, cost $13 500.

In the facts above presented we have an explanation of the wide difference in the cost of impregnating railroad ties according to the different systems. This cost averages, according to figures furnished by the German and Austrian railroad administrations, for each tie, as follows:

	Method of Impregnation.	Oak.		Beech.		Fir.	
		From	To	From	To	From	To
		Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1	Chloride of zinc	5.80	13.6	11.9	19.2	7.7	12.4
2	Blue vitriol....	8.7	18.2	21.8	24.3	14.5	20.6
3	Corrosive sublimate (not under pressure)	20.1	24.3	....	....	24.3	38.8
4	Creosote (under pressure)............	21.4	32 8	....	43.2	35.5	55.9

Impregnation with chloride of zinc is therefore by far the cheapest process, costing only one-half to one-fourth as much as creosoting, its most successful competitor.

V—Results of Impregnation.

The most interesting and important question with regard to the impregnation of ties concerns the results.

In consequence of the utter want of experience, definite information on the subject could only be obtained by careful observation and record. This was rendered extremely difficult by the many different factors derived from the nature of the wood, and the circumstances in which it was used, that had to be taken into consideration. Whether the timber was grown on light or heavy soil, whether the ties were laid in clean and porous, or in clayey and impermeable ballast; whether the upper surface is exposed to sun and air, or whether it is covered with ballast; whether the ties were first dried, or whether they were impregnated in a green condition, etc., all must exercise great influence on our question. All these circumstances received, when the observations were first undertaken, very little notice, as experience in the results of impregnation was entirely wanting, and it was therefore necessary to direct particular attention to them.

The statistics contained in the reports of the transactions of the technical conventions of the German Railroad Union, held in Dresden in 1865, in Munich in 1868, in Dusseldorf in 1874, and in Stuttgart in 1878, are unfortunately not so complete as might be wished, although the Dusseldorf meeting considered them sufficient to justify the following deductions:

"By means of impregnation a longer life is secured to the ties. The substances best adapted for this purpose are chloride of zinc and such as contain creosote. Blue vitriol and corrosive sublimate, in consequence of their higher cost and the difficulty of employing them, can only be considered as of secondary value."

At the Stuttgart technical convention it was ascertained that in 1877 the ties on 40 railroads in the German Railroad Union were impregnated, while in 1868 the process was only in vogue on 28; of these 40 roads, 5 used blue vitriol, 8 corrosive sublimate, 13 creosote, 20 chloride of zinc, and 5 a mixture of chloride of zinc and creosote. To understand these figures it is necessary to state that on several roads more than one system of impregnation is employed.

According to the unanimous opinion expressed by the roads taking part in the Stuttgart convention that have used any one of these systems of impregnation, the success of the process is indisputable, and none of these administrations have any idea of abandoning it.

All that is left for us to do is to choose the method that is most advantageous from a financial point of view, and in this respect the above-mentioned convention expressed itself as follows:

"As the experience of those railroads that have for from 25 to 26 years impregnated their ties with chloride of zinc under pressure after steaming and abstracting the sap (Hanover railroads, Brunswick railroads and others) has been very satisfactory, and as this system costs only one-half to one-third as much as impregnation with creosote, or corrosive sublimate, the majority of railroads have adopted the chloride of zinc process."

In spite of these favorable expressions of the latest technical convention, there still remain in Germany and Austria some 57 roads which do not impregnate their ties. We will, therefore, in the accompanying tables compare, according to the latest and most trustworthy results of the experience of the German Railroad Union, the durability of unimpregnated with that of impregnated ties, which will be found to support the theory that the impregnation of railroad ties is of financial importance.

TABLE A.

Comparative Durability of Unimpregnated and Impregnated Oak Ties.

The number of ties changed, expressed in percentage of the original laid, was:

From the First Year to the	Unimpregnated Ties.					Impregnated Under Pressure With		
	Emperor Ferdinand Northern R. R., 615 968 ties.	Hanover R. R., 565 261 ties, laid in 1845–47.	Cologne-Minden R. R., 140 108 ties, laid in 1846–48.	Berlin-Potsdam, 180 204 ties, laid in 1846.	Altona-Kiel R. R., 167 000 ties, laid 1843–44.	Chloride of Zinc—Hanover R. R., 168 690 ties, laid in 1854.	Creosote—Cologne-Minden R. R., 67 678 ties, laid in 1854.	Chloride of Zinc—Rheine-Emden R. R., 18 600 ties,* laid in 1854–55.
5th, inclusive....	0.54	0.61	0.29	.....	0.06	0.15	0.05	......
6th, "	1.25	1.14	1.88	0.34	0.19	0.20	0.30	......
7th, "	3.95	3.88	6.11	1.81	0.33	0.37	0.32	......
8th, "	8.93	6.04	11.27	3.46	1.13	0.52	0.53	......
9th, "	18.74	10.48	16.36	5.35	3.84	1.18	0.53	......
10th, "	25.70	14.92	20.29	8.12	6.71	2.20	0.78	1.0
11th, "	41.46	19.92	26.34	11.49	10.38	4.38	0.81	......
12th, "	74.73	26.09	38.97	15.63	16.64	8.02	1.02	......
13th, "	......	31.61	46.06	24.28	23.32	11.50	8.60	......
14th, "	......	34.33	52.73	30.89	38.27	....	12.79	5.2
15th, "	......	35.91	63.13	41.69	46.83	....	19.94	6.5
16th, "	......	43.51	71.39	50.01	55.29	....	21.82	7.8
17th, "	......	49.93	80.64	60.43	64.87	(20.73)†	26.03	9.5
18th, "	......	60.77	99.09	66.60	74.16	(27.97)†	30.09	12.2
19th, "	......	72.42	......	73.40	83.13	(31.38)†	36.72	21.4
20th, "	......	77.32	......	75.40	91.57	....	......	24.0
21st, "	......	79.33	......	......	93.35	....	......	27.88
22d, "	......	81.35	......	......	94.52	....	......	31 30
23d, "	......	......	......	......	95.31	....	......	35.33
24th, "	......	......	......	......	96.19	....	......	36.35
Average life......	10 years.	16 years.	13.5 years.	16 years.	15.1 years.	19.6 years.	19.5 years.	25 years.

Average life of 1 334 215 unimpregnated ties on 12 German railroads, 13.6 years.

*These 18 600 oak ties used on the Rheine-Emden Railroad were joint ties; the 161 615 pine ties in the following table were intermediate ties.

† The figures in brackets refer to 6 246 ties between Bremen and Sebaldsbrück.

TABLE B.

COMPARATIVE DURABILITY OF UNIMPREGNATED AND IMPREGNATED FIR TIES.

The number of ties changed, expressed in percentage of the original number laid, was :

From the First Year to the	Unimpregnated Ties.				Impregnated Ties.			
	Tilsit-Intersburg R. R., 68 291 ties laid in 1864.	Leipzig-Dresden R. R., 93 543 ties laid in 1856.	Schleswig R. R., 146 800 ties laid in 1854.	Oppeln-Tarnas R. R., 79 200 ties laid in 1856–57.	Boiled in blue vitriol—Berlin-Potsdam, Magdeburg R. R., 36 640 ties laid in 1850.	Steeped in blue vitriol—Lübeck-Bückden R. R., 60 000 ties laid in 1851.	Blue vitriol under pressure—Magdeburg-Wittenberg R. R., 111 044 ties laid in 1849–50.	Chloride of zinc under pressure—Rheine-Emden R. R., 161 515 ties laid in 1854–55.
5th, inclusive......	1.16	11.72	2.0	16.6	0.93	0.0	0.2	0.06
6th, "	4.02	23.11	8.2	37.5	1.97	0.0	0 8	0.16
7th, "	14.20	35.86	22.0	58.0	2.94	0.0	1.5	0.31
8th, "	32.02	47.10	51.5	77.0	4.73	1.0	3.0	0.60
9th, "	44.70	61.50	62.5	84.9	7.98	2.5	4.1	0.69
10th, "	55.82	73.70	75.5	91.9	12.11	5.8	5.8	1.10
11th, "	68.08	86.40	80.0	98.9	17.47	19.0	8.5	1.30
12th, "	78.52	100.00	86.5	......	23.99	30.6	12.6	1.40
13th, "	82.77	......	90.7	......	31.14	40.6	14.9	1.60
14th, "	......	......	......	......	38.50	49.0	17.3	2.7
15th, "	......	......	......	......	50.20	57.0	19.4	3.5
16th, "	......	......	......	......	66.20	66.0	20.9	5.7
17th, "	......	......	......	......	......	69.0	......	8.4
18th, "	......	......	......	......	......	......	......	13.3
19th, "	......	......	......	......	......	......	......	20.8
20th, "	......	......	......	......	......	......	......	26.9
21st, "	......	......	......	......	......	......	......	31.6
22d, "	......	......	......	......	......	......	......	37 3
23d, "	......	......	......	......	......	......	......	42.3
24th, "	......	......	......	......	......	......	......	46.3
Average life........	9.4 years.	7.9 years.	8.6 years.	7.0 years.	14.0 years.	13.9 years.	16.0 years.	22.8 years.

Average durability of 882 407 unimpregnated ties on 6 German railroads = 7.2 years.

Average durability of 831 341 ties impregnated, according to different systems, on 13 German railroads = 14.0 years.

TABLE C.

Durability of Pine and Beech Ties.

The number of ties changed, expressed in percentages of the original number laid, was:

From the First Year to the	Pine Ties.				Beech Ties.		
	Unimpregnated.		Impregnated with		Impregnated under Pressure with		
	North and South Union R. R., 233 640 ties laid in 1858.	Western R.R. of Saxony, 26 720 ties laid in 1858.	Chloride of Zinc by Steeping—Altona-Kiel R. R., 3 899 ties laid in 1852.	Blue Vitriol by Steeping—Aachen-Dusseldorf R. R., 32 348 ties laid in 1852–53.	Chloride of Zinc—Hanover R. R., 81 002 ties laid in 1852.	Creosote—Cologne-Minden R. R., 21 440 ties laid in 1855.	Chloride of Zinc—Brunswick R. R., 600 ties laid in 1852.
5th, inclusive	40.6	24.9	24.0	14.0	0.86	0.04	......
6th, "	62.4	66.5	33.0	21.0	1.56	0.04	......
7th, "	81.3	100.0	50.0	31.0	2.19	0.15	......
8th, "	94.6	......	73.0	41.0	2.72	0.76	......
9th, "	100.0	......	84.0	41.0	3.70	1.64	2.2
10th, "	......	......	91.0	49.0	4.90	3.91	7.2
11th, "	......	......	95.0	52.0	7.68	7.62	11.7
12th, "	......	......	98.0	......	13.06	13.66	39.3
13th, "	......	......	98.0	......	19.68	17.57	40.0
14th, "	......	......	98.0	......	25.40	20.05	40.0
15th, "	......	......	100.0	......	34.50	22 49	42 0
16th, "	......	......	......	......	......	24.48	......
17th, "	......	......	......	......	......	28.09	......
18th, "	......	......	......	......	......	31.89	.....
19th, "	......	......	......	......	......	44.97	......
20th, "	......	......	......	......	.....	46.91	......
The average durability is...	5.2 years.	5.1 years.	6.6 years.	9.6 years.	14.8 years.	17.8 years.	13.0 years.

Summary.

From the statements furnished above, as well as from other sources of information respecting the durability of ties, we will gather in concise form the most important conclusions.

1. The average life of unimpregnated ties on the German and Austrian railroads has been as follows, up to the present time:

For oak ties	13.6 years.
" fir "	7.2 "
" pine "	5.1 "
" beech "	3.0 "

2. The average life of ties impregnated in a rational manner with creosote or chloride of zinc, under a powerful pressure, reaches:

For oak ties	19.5 years.
" fir "	14 to 16 "
" pine "	8 to 10 "
" beech "	15 to 18 "

3. The average life of 831 341 pine ties on 13 German railroads, impregnated on various systems, is calculated at 14.0 years.

4. The plan of simply steeping the ties cold in the impregnating fluid, or warming them or boiling them therein, has been abandoned by most of the roads formerly practicing it, owing to its unsatisfactory results, and the system of impregnating under a strong pressure is being universally adopted.

5. A few roads steep their ties in corrosive sublimate without pressure, and are satisfied with the result.

6. The employment of blue vitriol for impregnation is being more and more abandoned in favor of chloride of zinc, because:

a. The result is not so satisfactory, which may be owing to the fact that only steeping, or at most a weak hydrostatic pressure, is employed for impregnation.

b. Because an expensive copper tank is required for the purpose.

c. Because the material itself is almost four times as expensive as chloride of zinc.

7. The results of impregnation of chloride of zinc and creosote are about equal. But as the impregnation with creosote costs about three times as much as with chloride of zinc, a majority of the German railroads have gone over to the latter.

8. An idea of the systems of impregnation now in use, compared with those employed in the years 1865 and 1868, may be gathered from the following table compiled from the report of the technical convention held in Stuttgart in 1878. (See Note at end of Appendix.)

9. In addition to the methods of impregnation, we have other circumstances that exercise considerable influence on the durability of the ties. Among them we may reckon especially the amount of traffic over

the road, the permeability of the ballast, the protection of the ties against rapid changes of temperature or degree of moisture by covering them with a layer of gravel, and the extent to which the ties had been dried before and after impregnation, and also before being laid.

Although we possess few figures respecting the influence of the above-mentioned conditions on the durability of ties, we find that the German Railroad Union collected a quantity of general experience, the result of which was the adoption of the following conclusions, unanimously or by a great majority, at the technical convention at Stuttgart in 1878 :

a. The ballast most favorable to the durability of the ties is that which is cleanest and most free from earthy particles, that allows the water to run through it easily, and is least affected by the vicissitudes of the weather.

b. That a covering of clean gravel, which protects the ties from the influence of the sun's rays, or, in other words, from light, and also from the rapid changes from heat to cold, and from wet to dry, is most advantageous for the preservation of the ties.

c. That a thorough air-drying of the ties before laying them on the road has a favorable effect on the durability, both of impregnated and unimpregnated ties.

d. That ties made from timber felled in winter, especially when they are not impregnated, have been found, after many years' experience, to possess much greater durability than those made from trees felled in the summer.

e. That, to insure successful results, all ties that are to be impregnated with creosote under pressure, or by steeping in corrosive sublimate, must be thoroughly air-dried or artificially dried before impregnation, whereas such ties as have been steamed and deprived of their sap previous to being impregnated in partial vacuo with chloride of zinc or blue vitriol do not require to be dried.

While from the foregoing we may recognize the advantages of impregnating ties, even in the case of a road which can obtain wood at comparatively low prices, I will add a few calculations, which, although to a certain extent based on estimates, will show the great economical importance of impregnating railroad ties.

Of the 60 000 000 ties—speaking in round numbers—that are laid on the German and Austro-Hungarian railroads, about 25 000 000 are impregnated; the remainder being unimpregnated. Of the latter, some 15 000 000 are of oak; the remainder of pine, fir and other soft woods. According to the foregoing tables, the average life of an oak railroad tie, when unimpregnated, is about 13.6 years; when impregnated, 19.5 years. And the average life of fir and pine ties, unimpregnated, is 6.1 years; impregnated, 12.0 years.

Taking the average price of unprepared oak ties at $1, and pine and

spruce ties at 62½ cents, and supposing the cost of impregnation, including interest and sinking funds for the capital invested in the construction of the impregnating works and transportation (taking into consideration the constant spread of the system of impregnating with the cheap chloride of zinc), to be about 12.5 cents for oak ties, and for pine or spruce ties about 15.0 cents, we obtain the following results in round numbers: The 15 000 000 unimpregnated oak ties have cost $15 000 000, and represent, with their average life of 13.6 years, a yearly expenditure of $1 102 500. The 20 000 000 unimpregnated fir and pine ties, at 62.5 cents, have cost $12 500 000, and the necessity of replacing them every 6.1 years represents an annual outlay of $2 047 000. The cost of maintaining the unimpregnated ties amounts therefore to $3 150 000.

Had they been properly impregnated the 15 000 000 oak ties at $1.12½, including impregnation, would have cost $16 875 000, and, with an average life of 19.5 years, would have entailed a yearly expense of $865 000 for replacement; while the 20 000 000 pine and spruce ties, at the rate of 77 cents, would have cost $15 500 000, and, lasting an average 12 years, they would have cost annually $1 350 000 for replacement.

The cost of replacing the 35 000 000 unimpregnated ties we have shown to be $3 150 000; while, had they been impregnated, they would only have cost annually $2 215 000. *By impregnating those ties we should, therefore, have saved each year* $935 000.

Such figures call loudly enough for the universal introduction of the impregnation of ties, and require no further explanation.

There is but one thing more we should like to say.

Those who do not find the foregoing, which is the experience hitherto obtained of the success and financial importance of impregnation, sufficiently convincing, will have little chance of being speedily convinced, as the continuance of statistical observations respecting the life of impregnated and unimpregnated ties has greatly increased in difficulty, and indeed has almost ceased.

Toward the end of the period of renewal the ties that were originally laid are very difficult to distinguish from those that were replaced later. A second period, when further experience will be possible, will only occur when the proceeding recommended at the technical convention of 1868 in Munich, and confirmed and again recommended at the Stuttgart convention in 1878, has been generally adopted for a series of years; it consists of driving into every tie, when laid, a nail, bearing, impressed on its head, the date of such laying. We cherish the hope that the number of roads will be small that will wait for the results reported at the expiration of the second period before being convinced of the advantages of impregnation, and the great saving in the maintenance of railroads effected by this process.

NOTE.—The table referred to was not in the translation, but the information has been obtained from another source.

At the Technical Convention of the German Railway Union, July, 1884, a report on preserved sleepers was presented, which was supplementary to a previous report published some years ago. Of the railways answering the circular of inquiry sent out by the committee, 34 use preserved sleepers now, against 24 in 1868. The number of railways using each of the methods of preservation in 1865, 1868, 1878 and 1884 was:

	1865.	1868.	1878.	1884.
Sulphate of copper	15	6	5	1
Sulphate of iron and zinc	1	..	..	..
Sulphate of barium and oxydul of iron	2	..	..	..
Corrosive sublimate	3	6	8	4
Chloride of zinc	8	7	20	22
Creosote	4	5	13	11
Chloride of zinc and creosote mixed	..	..	4	7
Vapor of creosote (Paradis' patent)	..	..	..	1
Vapor of creosote and creosote (Blythe's system)	..	..	1	1
Antisepticum under pressure	..	..	..	1

Thus sulphate of copper, which was the prevailing method used in 1865, is now used by but 1 railway; but the use of chloride of zinc has extended until it prevails, and, alone or in combination with creosote, is used by 29 out of 48 railways which use any preservative. Creosote alone, however, is still extensively used, though less so than in 1878.

APPENDIX No. 7.

Report of M. Alexander, Esq., Roadmaster and Engineer Chicago, Rock Island and Pacific Railway.

Blue Island, Ill., March 23d, 1882.

H. Riddle, Esq.,
Pres't C., R. I. & P. R'y.

Dear Sir,—In reply to your letter of March 15th, asking for dates, etc., regarding ties that have been subjected to different kinds of treatment and laid in track on the C., R. I. & P. R'y, I can only give you the results of two lots of ties that have been treated, one of which was Burnettized and the other creosoted.

November, 1866, we laid in main track just west of Englewood about 2 000 soft-wood ties, consisting of pine, tamarack and cedar, but the greater portion of them were hemlock. These ties were all treated to a solution of chloride of zinc, and have sustained a very heavy traffic.

They are laid in a fine gravel ballast, and have received just the same attention that ties have on other parts of the road.

I made a careful examination of these treated hemlock ties last summer, and found at least 75 per cent. of them still in the track, and, in my opinion, in such a state of preservation that they will be serviceable for two or three years longer. Some five or six of these ties were taken out of track and found to be sound and solid in the center, and only decayed to the depth of ½ to ¾ of an inch on the surface and sides. The rail has not worn into these hemlock ties to any greater extent than would have occurred with oak, and they hold a spike fully as well as the oak tie. The pine and cedar ties that were Burnettized at the same time have worn out in the 15 years' service, and have disappeared. The tamarack have held out about the same as the hemlock.

My experience is that untreated hemlock ties decay first in the center, or heart, when the spike becomes loose, and the tie crumbles; but these treated ties are sound in the center, which shows that where the chloride of zinc is not washed out the wood is in a perfect state of preservation.

In 1872 we laid in second track, east of Washington Heights, about 5 000 hemlock ties that were subjected to the creosoting process. These ties, I do not believe, were thoroughly treated; they seem to be tolerably sound at the bottom, but are badly decayed on the surface, and the rail wears into them to a much greater extent than it does into those that were treated with chloride of zinc. There is probably not more than from 30 to 50 per cent. of these creosoted ties now in track, and these will no doubt all be taken out this season.

I find that the natural life of a hemlock tie, laid in sand or gravel ballast, does not exceed five years; but if thoroughly treated with chloride of zinc, I believe they will last at least fifteen years. The creosoting process, if thoroughly done, will no doubt double the service of soft wood ties.

For any further information I would refer you to M. Lassig, who was in the employ of L. B. Boomer in 1866 and 1867, and who had charge of his Burnettizing works at that time, and subjected large quantities of bridge timber to treatment.

Respectfully yours,

(Signed) M. Alexander.

APPENDIX No. 8.

BURNETTIZING ON LEHIGH AND SUSQUEHANNA R. R.

BROOKLYN, April 24th, 1883.

O. CHANUTE, Esq.,

Chairman Committee on Preservation of Timber.

DEAR SIR,—Soon after receiving your circular asking for information regarding "preservation of timber" I went to Mauch Chunk, and calling upon Mr. Twining, Roadmaster of the L. & S. Division of the C. R. R. of N. J., he very kindly accompanied me to a portion of his track in which were a quantity of Burnettized ties which have been in the track since 1867 and 1868.

The track in which these ties are laid runs along the river bank, and is in a side-cutting, in rock principally.

The ties in question consist of maple, beech and hemlock. They were mixed indiscriminately with untreated ties at the time of laying, with one, two or three in a place. With a few exceptions they have resisted decay almost perfectly. The rails have worn into them from one-fourth to five-eighths of an inch.

The beech ties that were treated had stood well, showing very little, if any, decay; but being straight-grained, they had, in some cases, split through the heart, beginning at one end, which was open from 1 to 3 inches, and extending half or two-thirds of the length of the stick.

The effect of treatment upon the hemlock ties appeared to be the best of all. They were very hard to cut, dulling the knife, and where cut presenting a glassy appearance. They were generally much harder and, consequently, less worn by the rail than any of the other woods.

Most of the treated ties in the track appeared good for 7 or 8 years longer. A few of the treated ties had been taken out of the track and piled alongside, but many of them apparently were removed unnecessarily. In nearly all cases the under sides of these ties appeared like new timber.

As an experiment, the value of the operation was greatly vitiated by mixing these ties with untreated ones, in such a manner as to render it difficult to ascertain the effect of the treatment in promoting resistance to wear under the rail.

I also examined some creosoted * cypress ties which were laid in the track of the C. R. R. of N. J., near Bound Brook station, in the year 1876, several hundred feet of track being laid exclusively with ties thus treated. They are sound, very slightly worn, and will no doubt serve a good purpose for several years longer, probably 10 or 12 years.

These ties can easily be found in the track, both from their blackened appearance and by the odor.

---

* Virginia pine.—E. R. A.

The Burnettized ties can be picked out from among the others by the somewhat weather-beaten appearance of the surface, as well as from the fact that an end of each was stamped with figures showing the date at which they were laid in the track.

Respectfully yours,

L. L. BUCK.

APPENDIX No. 9.

BURNETTIZING ON HAVRE DE GRACE BRIDGE.

HAVRE DE GRACE, March 18th, 1882.

O. CHANUTE, Esq.

DEAR SIR,—I have your circular of the 15th, in regard to preservation of timber. All of the timber used in the first building of the Susquehanna bridge at this place was Burnettized. I have no experience with any other process, and no experience of any kind with treatment of cross-ties. I give you copy of report made to me in 1866 by the superintendent of the works as regards the Burnettizing process. "The process of Burnettizing is as follows: The timber to be operated on is loaded on trucks, run into cylinders on the railway track, and the heads of the cylinders are closed and securely bolted. Then a vacuum is obtained by the air-pump, and maintained until the sap and impurities of the wood are extracted, a period varying from 20 minutes to 2 hours, according to the dimensions and kinds of timber. At the expiration of this time a diluted solution of chloride of zinc is let in from the tank below the cylinders. This occupies about 15 minutes. When full the force-pump is applied, and a pressure of from 100 to 150 pounds to the square inch is obtained, and kept on from 1 to 4 hours, the time depending as before upon the dimensions and kind of timber.

"By the two (2) cylinders from thirty thousand (30 000) to forty thousand (40 000) feet, b. m., of timber can be Burnettized in a day. The chloride was all made under the immediate supervision of a skilled agent of the railroad company in order to insure a reliable article. The strength of the diluted solution used was one and twelve-one-hundredths ($1 \frac{12}{100}$) pounds of concentrated solution to one hundred (100) pounds of water, or about eighty-five-one-hundredths ($\frac{85}{100}$) of an ounce to the cubic foot of timber prepared." I also give you a copy of letter to C. H. Latrobe, Esq., on March 6th, 1882.

"I have yours of March 4th this evening. The weight as measured by Burnettizing is about 8 per cent., and this increase remains after seasoning. The durability, as against ordinary decay, is wonderfully increased. I have about my place a large quantity, Burnettized as long ago as the early part of 1866 (some of it probably a year or two earlier

than that). A shaving taken off with a penknife reveals clear, bright timber. I think I can safely say that I have yet to see the first piece of decayed Burnettized timber. The strength, as against cross-strains, is reduced at least 10 per cent. (probably more), against strains of extension or compression I do not think it is injuriously affected.

"The injurious effects were especially noticeable in the bottom chords, where, as is usual with the Howe truss, the floor beams rested on the chords. No evidence of weakness was discerned in braces or top chords.

"The difference in the break of Burnettized and non-Burnettized timber is such that I could, in every case, and certainly and speedily, without considering the difference in color, distinguish the one from the other.

"The breaks would be about as follows:

"1. In Burnettized timber it would be in an abrupt, ragged line, nearly directly across the stick of timber.

"2. In the non-Burnettized timber it would be in a long, very ragged line, running more or less diagonally across the stick of timber, showing much less brittleness of fiber. A piece of timber not Burnettized may break like number one, but a piece of Burnettized timber will never break like number two. These statements refer to pine timber and are the results of very careful experiments and of observation extending over sixteen years."

Yours respectfully,

Edward Larkin.

APPENDIX No. 10.

Description of Thilmany Process.—American Wood Preserving Works.

Defiance, O., Sept. 10th, 1882.

We have preserved all dimensions and all kinds of timbers. In Milwaukee mostly pine and oak for paving blocks and bridges and building timbers.

In Defiance we use for railroad ties all soft timber, as elm, ash, maple, sycamore, etc. We preserved all dimensions from paving blocks 6 inches high and 3 or 4 inches thick up to timbers 40 feet long, 20 x 24.

We prefer green timber; dry timber has to be steamed much longer. Only live and sound timber can be preserved.

Description of the Process.

The timber is run on flat cars into a cylinder 6 feet in diameter and 80 feet in length. Steam is applied, which thoroughly drives out the sap. A powerful air-pump, connected with the cylinder, is set in opera-

tion, for the double purpose of extracting the condensed steam contained in the timber and of exhausting the air to form a vacuum. The cylinder is then filled with a solution of sulphate of copper or sulphate of zinc, and, by means of a force-pump, a pressure of 80 to 100 pounds to the square inch is applied. This pressure is kept up until all the pores of the wood are charged with the solution.

Now comes the most important point of the process, namely, to change soluble sulphate of copper or sulphate of zinc into an insoluble salt of sulphate of baryta.

For this purpose, the boiler is filled the second time with a solution of chloride of barium, and the same pressure as before applied. By means of this pressure and chemical affinity between the sulphate of copper or sulphate of zinc and the chloride of barium, a chemical combination takes place, forming the above described insoluble salt of sulphate of baryta and chloride of copper or chloride of zinc, which fills the interstices of the fiber, petrifying the pores, while a part of the chloride enters into a combination with the organic substances of the fiber of the wood. The timbers, being thus thoroughly impregnated, are now ready for use.

We have used a solution of 1½ per cent. blue vitriol and 1 per cent. of chloride barium. We have found this solution (the same as used in Europe) satisfactory for the preservation of pine and white oak timber, but not sufficiently strong for timbers growing in a swampy country, as, for instance, the timber near Defiance. It seems to me that this kind of timber contains too much condensed steam (after steaming), on account of the swampy growth, and, therefore, the solution entering the pores will be much weakened. Therefore, we use now a 2 per cent. solution of blue vitriol and 1½ per cent. chloride barium, but I would recommend, where sulphate of zinc is used, to take a 3 or 3½ per cent. solution.

The time occupied is different and depends upon the size of the timbers. For railroad ties it takes 12 hours; for larger timbers it requires more time.

We had excellent tests for preserved timber for use in breweries, as will be shown by the following letter of one of the proprietors of the largest brewery in the United States:

OFFICE OF PHILIP BEST BREWING COMPANY,
MILWAUKEE, WIS., February 18th, 1880.

Mr. A. E. BARTHEL, Detroit, Mich.

DEAR SIR,—In answer to your letter of February 14th, inst., in regard to the Thilmany process for preserving wood and timber, I can but honestly inform you that said process is a success.

We have at our city several blocks of streets and approaches to bridges paved with wood thus preserved, and find that after several

years of hard usage the wood is tougher than it was in its unpreserved state. We cannot detect any rottenness whatever. Last fall we put about six blocks of street in the Fifth and Eighth wards. These observations influenced our firm to have all timbers, heavy joists, planks and flooring needed at our new ice-houses, and for other purposes, to undergo the Thilmany process, regardless of the difference in cost. Five years ago we had the ceiling at our South Side brewhouse constructed of wood thus impregnated, and find joists and ceiling floor in as good a condition as when put up. Heretofore we had to replace same ceiling made of natural wood almost every three years, owing to the dampness and cold and warm vapors produced in a brewhouse. The wood not impregnated but painted went to a quick rot and decay.

Hoping this information will be to your satisfaction, I have the pleasure to remain,

Yours respectfully,

EMIL SCHANDEIN.

Soft timber would be considerably hardened by this process.

The city of Milwaukee has used prepared timber in large quantities for pavements, water boxes, etc., and the Board of Public Works of said city could give valuable information about this process. As said before, we would recommend the use of zinc for railroad ties, and we are willing to make a contract with railroad companies who are willing to pay such a price (25 to 30 cents a tie for preserving), that a solution of 3½ per cent. can be used, to guarantee 80 per cent. of the preserved ties for a period of 12 years, and to give the necessary security.

O. THILMANY.

APPENDIX No. 11.

DESCRIPTION OF THE WELLHOUSE PROCESS.—ST. LOUIS WOOD PRESERVING COMPANY.

ST. LOUIS, August 8th, 1882.

O. CHANUTE, Esq.,

Chairman of Committee on Wood Preserving, American Society of Civil Engineers.

DEAR SIR,—Your favor of June 3d, 1882, received and noted.

I consider wood thoroughly creosoted superior to all other for outdoor purposes where the wood has to sustain no considerable wear, or transverse stress, such as piling, foundation plank or timber laid in the ground.

But the question is, is it practical to thoroughly creosote green or partially seasoned timber, such as is used on our American railways, without injuring the wood fiber, in preparing same to receive the oil.

The treatment of wood, either with oil or a mineral salt, is of little value in my opinion, unless the material used is injected throughout the wood.

Should oil be used and not be injected throughout the entire wood (as at St. Clair Flats by the Seely process, and on the Chicago, Rock Island & Pacific Railroad, same process), little or no benefits would be derived; but had a mineral salt been used, and a sufficient quantity injected to have preserved the timber, or ties, even though at time of treatment the solution had not extended throughout the entire wood, it would, within a few days, or short period of time, have equalized with the moisture throughout the wood, which would not be the case with oil.

In my opinion, when oil is used, say in such wood as cypress (which when in condition to be thoroughly treated will take from two (2) to four (4) gallons of oil to the cubic foot), should a less amount be used than is necessary to treat the wood throughout, the result would be to preserve that portion of the wood throughout which the oil penetrated, leaving the remaining portion in worse condition than before treatment.

If it were possible to inject the oil thoroughly throughout the wood, and then remove a portion of same, it would answer well; but it is impossible to treat wood throughout with oil without injecting into said wood all it will take.

I consider that timber first injected with a mineral salt, such as chloride of zinc, and subsequently with creosote, is superior in every respect to fully creosoted wood, for the following reasons:

So far as my experience goes, it is impossible to remove sufficient moisture from green or partially seasoned wood to thoroughly creosote same, without materially injuring the fiber of the wood, which, for railway ties or bridge timber, is a serious objection.

By first injecting into the wood the chloride of zinc, and then removing the moisture from the outer portions, you can, without subjecting the wood for a long period of time to excessive heat, inject throughout said outer portion oil to the depth of one-quarter (¼) to one (1) inch or more, thereby securing all the benefits derived from the oil, where the tie or timber comes in contact with the ground, as well as insuring the thorough treatment of the wood throughout with the chloride of zinc, which is protected by the oil surrounding it, thus preventing its being chemically changed or washed out.

At St. Clair Flats, wood treated by the Seely process, which was not creosoted throughout, rotted at the heart, the surface remaining perfectly sound.

On the Rock Island Railroad, the Burnettized ties remained sound

at the heart, but decayed at the surface where they came in contact with the ground. Imperfectly creosoted ties on same road remained sound at the surface, but rotted at the heart.

Now I claim that if said ties or timber had been treated by the zinc-creosote process, they would have remained sound throughout.

It costs about seventy-five (75) per cent. less to treat by the zinc-creosote process than to fully creosote, and I am satisfied much better results will be obtained, on account of the certainty of impregnating the wood throughout with the mineral salt.

With reference to the zinc-tannin process, as practiced here :

We steam our wood three (3) hours or more, according to the diameter of the timber. We use chloride of zinc, one and ninety-one-hundredths (1.90) per cent. strong, glue and tannin, injecting the chloride of zinc and glue at same time, afterward subjecting the timber to a bath of tannin under pressure. Our object in injecting the glue with the zinc is to destroy all the tannic acid that may be in the wood. At the same time we precipitate a portion of the glue, thereby forming an insoluble leathery substance for which the chloride of zinc seems to have an affinity.

Afterward, with the bath of tannin, under pressure, we precipitate that portion of the glue remaining in the outer pores of the wood, thereby retaining in the wood a greater per cent. of chloride of zinc than would remain if simply Burnettized, as we have ascertained by experiment.

H. W. Scheffer, analytical chemist, this city, under date of October 14th, 1879, says : "The oxide of zinc has been determined directly, while the chloride was only calculated, on account of the impossibility to wash the chloride out of the chips. I have come to the conclusion that it is either retained by the woody fiber, or has formed an insoluble compound which prevents its extraction by water. The gelatine and tannin could not be determined on account of want of material ; however, tannin was found present in the watery solution, which in itself excludes the presence of gelatine."

Chauvenet & Blair, chemists, under date of June 19th, 1880, say : "Samples of wood left us, after being reduced to shavings, were boiled with three successive portions of water, in all three hours. Being then dried and analyzed, they yield chloride of zinc eight hundred and twelve thousandths (0.812) per cent."

Brandt V. B. Dixon, chemist, June 10th, 1880, says : "After boiling fine glass scrapings four hours, the water showed no trace of zinc. After drying assayed three hundred and eighty one thousandths (0.381) per cent. zinc-chloride."

The timber as we receive it here takes, per cubic foot, about as follows, viz.: Cypress, gum, white pine and other like woods, from one and a half (1½) to two (2) gallons of solution ; cottonwood and elm, say

three to four (3 to 4); black oak, one (1) to one and one-half ($1\frac{1}{2}$); white oak, one-half ($\frac{1}{2}$) to three-quarters ($\frac{3}{4}$); yellow pine, hemlock and mountain pine, from one and a half ($1\frac{1}{2}$) to two (2) gallons.

Our method of injection is by pressure after steaming. Time occupied, from nine (9) to twelve (12) hours.

We have treated, say one hundred and fifty thousand gum and black oak railway cross-ties, besides some fifteen million feet of bridge and other timber.

The St. Louis Wood Preserving Company's charges for treating timber by the zinc-tannin process are eight dollars ($8) per thousand feet, b. m; railway ties, twenty (20) to twenty-five (25) cents each.

Our principal business is with the railroad companies (bridge timber, ties and the like).

We have treated gum wood, which has now been in the ground nearly four (4) years, that is as sound to-day as the day it was cut. If not treated, would show signs of decay in less than ninety (90) days, under similar conditions.

Our treatment hardens the timber, and our aim is not to affect the strength.

The ties heretofore mentioned are sound in every respect, while many untreated white oak ties, laid in same track at same time, show unmistakable evidence of decay.

I am convinced that ties treated by the zinc-tannin process will in most kinds of soil wear out before they will decay. I would not recommend the zinc-tannin process when timber or piles are submerged in water, not through any fear of its being washed out, but on account of the impurities in most water, which in time may transform the chloride into a non-antiseptic.

With regard to the treatment of wood by the Boucherie process, and by absorption :

My belief is that it is not possible to treat most, if not all kinds of wood, by either of these processes, when the wood is dry or partially seasoned.

I am satisfied that in order to treat successfully by the Boucherie process it is necessary to treat the timber at such seasons of the year as sap is flowing, and immediately after its being cut; otherwise the sap will solidify in the pores, and prevent the penetration of the solution used.

In case of Kyanizing, it would be necessary to take the wood immediately after being cut, and while full of moisture, to enable or admit of the equalization of the salt used, with the moisture throughout the wood. Should it be dry or partially so, the air within the wood would prevent contact of the solution and moisture, which is necessary in order that they may equalize. On the other hand, after steaming and vacuum, the wood is expanded, fiber softened, the gummy portions of the sap dis-

solved, made liquid or driven out, and the air expelled, leaving the wood in condition to receive the solution readily, and without obstruction, which would not be the case if treated by the Boucherie process, by Burnett's, as I understand it was practiced at Lowell, or by absorption, except in the latter case possibly by many weeks of immersion.

I send you, by express, a cross-section of each of the following, viz.: a seventeen (17) inch cypress pile, a twelve by twelve (12×12) square pine timber, an oak railway tie and an ash stick, all treated by the zinc-creosote process.

Trusting I have answered your inquiry in full, without being tedious, I remain

Respectfully yours,

JOS. P. CARD,

President.

APPENDIX No. 12.

DESCRIPTION OF THE GYPSUM PROCESS.—AMERICAN WOOD PRESERVING COMPANY.

ST. LOUIS, November 3d, 1883.

O. CHANUTE, Esq.,

Chairman Committee on Preservation of Timber.

DEAR SIR,—Your circular on "Preserved Timber," having reference to a selection exhibited at the National Exposition of Railway Appliances at Chicago, was handed to me only a few days ago by a friend, and naturally interested me very much.

Our company has lately purchased the creosoting works of the former Western Wood Preserving Company, and having acquired the patent of E. Hagen for treating wood with tincture of zinc chloride and gypsum in one solution and charge, we now apply this process to railroad ties, car-roofing and siding, etc., successfully, passing all lumber to be worked after the treatment through an excelsior drying kiln (Curran & Wolff) in order to season it perfectly.

We claim that by our combination of gypsum with the tincture of zinc chloride a crystalline covering of the fibers of the wood throughout will prevent the washing out of the chloride and thereby do away with the main objection so far made to this excellent antiseptic.

Since our process is quite young yet, we, of course, have no other proofs to substantiate our above claim than the testimonials of chemists, and I take the liberty to call your special attention to the one of Prof. C. Gilbert Wheeler, of Chicago, copied in our pamphlet, which I mailed you to-day.

We submit also the following certificate of analysis:

WASHINGTON UNIVERSITY,
MINING AND METALLURGICAL LABORATORY,
ST. LOUIS, MO., October 11th, 1883.

GENTLEMEN,—The samples of preserved wood from the American Wood Preserving Co. marked Cypress No. 5, Yellow Pine No. 9, Black Oak No. 13, submitted to me for examination, yielded when treated with hydrochloric acid:

	Cypress.	Yellow Pine.	Black Oak.
Chloride of zinc..	0.078 per cent.	0.096 per cent.	0.065 per cent.
Sulphate of lime..	0.360 "	0.250 "	0.232 "

Determinations made after charring wood at low temperature gave for sample as received:

	Cypress.	Yellow Pine.	Black Oak.
Chloride of zinc..	0.310 per cent.	0.249 per cent.	0.279 per cent.

This shows that even hydrochloric acid is not capable of extracting the zinc from the wood to any considerable extent.

A weighed portion of the borings from the different woods was digested in distilled water for 48 hours and the water was found to be free from zinc and lime, showing that none of these substances was dissolved from the wood. They appear to be practically insoluble in water as they exist in these samples of wood.

Respectfully,
WILLIAM B. POTTER.

Knowing that Prof. N. T. Lupton, of the Vanderbilt University at Nashville, Tenn., is recognized all over the Southern States as one of the most eminent analytical chemists of the country, and that his opinion, if favorable to our process, would have great weight, we sent him several specimens of wood of the same treatment as above, and we received from him the following certificate of analysis:

VANDERBILT UNIVERSITY,
CHEMICAL LABORATORY,
NASHVILLE, TENN., October 29th, 1883.

The samples of wood from the American Wood Preserving Co. have been carefully examined, with the following results:

	Cypress.	Black Oak.	Yellow Pine.	Cot. Wood.	Hard Gum.
Moisture expelled at 210° to 215°..	12.37 p. c.	11.98 p. c.	12.02 p. c.	12.11 p. c.	11.94 p. c.
Metallic zinc.....	0.096 "	0.070 "	0.087 "	0.083 "	0.076 "
Equivalent to zinc chloride	0.199 "	0.145 "	0.161 "	0.172 "	0.158 "
Lime as sulphate.	0.400 "	0.224 "	0.336 "	0.252 "	0.312 "

Weighed portions of the different kinds of wood were subjected to the action of distilled water with frequent agitation for three weeks, without giving the least evidence of the solution of the zinc and lime salts, with which they are impregnated.

The above determinations were made from sawdust, obtained by sawing entirely through the specimens examined. The zinc and sulphate of lime permeate the wood completely, and seem to be in the best condition possible for exerting their preserving qualities.

Very respectfully,
N. T. LUPTON, Prof. Chem.,
Vanderbilt University.

An expression of your opinion in regard to our treatment would be highly appreciated, and if your association should find it of sufficient importance to closely inspect and analyze it, I shall be very glad to send you samples of any kind of wood within our reach you may designate.

Hoping to be favored with an early reply, I am,

Yours respectfully,

THEO. PLATE,
President.

APPENDIX No. 13.

CREOSOTING ON NEW ORLEANS AND MOBILE RAILROAD.

NEW ORLEANS, LA., June 20th, 1885.

O. CHANUTE, Esq.,
Chairman Committee on Preservation of Timber.

DEAR SIR,—The line of railroad between New Orleans and Mobile runs parallel to and near the coast, crossing various arms of the sea, and so near the mouths of rivers that the tide ebbs and flows a considerable distance above the railroad crossings. The salt water flows over the bar at high tide, and at the ebb the fresh water, being lightest, flows over the top, leaving a basin of salt water in which the *teredo navalis* finds some of his choicest feeding grounds. As the tidal rise is only a foot or two, the tidal currents are not very strong. It often happens that piles driven for these bridges will be honeycombed from five to forty feet below the surface of the water, while not a sign of the *teredo* can be found at the surface.

In the construction of the road the bridges over these waters were built of unpreserved piles and timber. Before the road had been fairly completed it was found that the piles were being rapidly destroyed by the *teredo*, and before trains had been running six months a part of the bridge over Bay Biloxi gave way, precipitating the locomotive and part of the train of freight cars into the bay. Realizing that something must be done to protect the piles, and knowing of no method of reliably treating them, it was decided to sheath them with metal. Between four and five thousand piles were sheathed, part with yellow metal, such as is used for covering ships' bottoms, and part with zinc, with a layer of felt underneath. Four or five hundred were charred and oiled, and as this was less costly than covering with metal, more piles were thus treated subsequently.

The zinc corroded rapidly, and in about three years there were many small holes through it. It served as a partial protection until the bridge was rebuilt with creosoted piles, eight years later. The felt underneath did good service after holes came in the zinc. The yellow metal was

more durable and did not show many holes for six years. When taken off in eight years many sheets had lost all toughness and broke like plates of glass. The charred and oiled piles were about as durable as zinc. In charring timber, there are narrow lines or strips of clear wood between the coals, and into these, as well as places where the coal gets chafed off, the marine animals enter. It appears that there is great differences in the durability of metals in different waters, owing to the ingredients leached out of the earth and brought down by the streams. In some harbors sheet copper is reported good after forty years' service, while in others it will be destroyed in five years.

An outline history of the use of timber on the New Orleans and Mobile Railroad will apply to most roads in the South that have used the same kinds of timber.

A large amount of long-leafed yellow pine and quite a quantity of cypress was used in the construction of the road in the years 1869-70. In the year 1874 extensive renewals were required. In 1875-76 still more extensive renewals were demanded.

The decay was so rapid, especially with the horizontal timber, that in the last bridges rebuilt in 1879 probably not more than 5 per cent. of the original pine stringers and caps remained. But some of these were sound and would probably have lasted two or three years longer. Some of the timber which had been put in to replace that which first decayed had become so rotten as to require renewal.

The cypress was much better than the yellow pine, and estimating from recollection, I think that not more than 25 per cent. of the cypress had been removed on account of decay. Black cypress is much the most compact, heavy and durable of any kind that I have used. The red comes next, while the white cypress is but little better than good yellow pine. For cross-ties it is not as good, except in straight track, being too soft to hold the spikes and rails.

I think through the Southern States, where there is a long, warm season favorable to fermentation and decay, yellow pine may be expected to last from five to ten years, and red and black cypress from ten to twenty for ordinary trestle bridge work where kept up free from the ground. There is little timber other than pine and cypress suitable for bridge work in this section of country.

In 1875 it was decided to rebuild all the bridges on the road with creosoted piles and timber, under the supervision of the writer, who had been investigating the subject for two or three years. Quite a number of parties were creosoting timber for various purposes, and at first it was thought practicable to contract with them for the required material. Examination of their products and of the oldest creosoted work that could be found convinced the writer that if creosoting could be properly done, it would be good and effective; but if it could not be better done than any one was then doing it, it had better be let alone. Paving

blocks, planks and piles were being treated under various patents, but always with oil at a potency that would make glad the heart of a high dilution homeopathist. By their peculiar methods of doing business they drove from the field and almost out of use the best and most durable kind of paving for driving and ordinary street wear that has ever been laid. It is noiseless; it is elastic under foot, so that horses can endure speed and service; it is not slippery, and therefore safe. The result, the general suspension of creosoting, might have been anticipated. Wherever a piece of timber could be found which had been saturated with oil it was perfectly sound, and these isolated specimens were the evidences that convinced him that creosote was a specific against decay and the ravages of marine animals, if properly used.

After a series of experiments plans were adopted differing considerably from anything in use. Works were constructed at West Pascagoula, Miss., and the work of reconstructing the bridges with creosoted piles and timber commenced about the first of March, 1876. The result of the first year's operations gave a consumption of 1.8 gallons of oil (equal to 15 or 16 lbs.) per cubic foot of timber treated. This included piles and sawn timber, but piles will absorb more oil than hewn or sawn heart timber. Nearly all the timber treated was long leaf yellow pine. It included piles and timber for superstructure and water-ways and culverts. Our opinion now is that for marine purposes not less than two gallons of oil should be used per cubic foot for yellow pine. For spongy, porous timber a much larger amount will be required to give an equally uniform and safe treatment. For fresh water or dry land work a less quantity will give good results, but the amount should be proportioned to the kind of timber used, solid, compact timber requiring the least. Timber should be heated through to above 212° F. (whether dry or green), and have the air and moisture exhausted, and in that condition receive the oil.

We did not gauge ourselves to any given quantity of oil per cubic foot, but endeavored to make the work as thorough as practicable. We did not thoroughly saturate through and through the piles or sawn timber, and I do not think any process is known whereby solid, compact timber of large size can be thoroughly saturated by a one or two days' treatment.

The bridge over Chef Menteur was the first to be rebuilt of creosoted timber, and this was done during the months of March, April and May, 1876. It is an iron truss with spans of 110 feet, resting upon pile piers of 16 piles each, each pile capped with a cast-iron socket, and the whole surmounted by a wrought girder pier-head upon which the truss rests.

The stringers, cross-ties and guard-rails are of wood.

All the wood-work of the bridge, including piles, was as thoroughly creosoted as practicable, having an average of nearly two gallons of creosote oil per cubic foot.

The bridges over the mouths of Pascagoula River were next built in the months of May, June and July upon the same plan.

During the summer of 1876 several small structures, culverts and water-ways were built entirely of creosoted timber, and also a sheet piling revetment along the sides of the embankment, across Lake Catharine, which is nearly a half mile long.

This revetment was built of creosoted inch plank, driven double, so as to break joints, and bearing against a wale plank or stringer, supported by piles on the outside.

During the following winter the bridge across the Great Rigolets, nearly three-fourths of a mile long, was built. The piles in these structures are subject to attacks of the *teredo navalis*, especially those at the crossing of the Pascagoula River, where piles a foot and a half in diameter have been cut off by the *teredo* in a single year.

During the summer of 1877 no creosoting was done, but during the fall, winter and spring following a great number of water-ways and trestles, and the bridge over Pearl River were built. The water in these large streams is from 15 to 45 feet deep, and piles were used from 40 to 95 feet long.

During the month of June, 1885, I examined the bridges built nine years ago. I bored a great number of cross-ties, stringer timbers and piles (always plugging the holes with a creosoted pin), selecting such as I thought most likely to show signs of decay, if any existed. Every piece of timber was in perfect order, the wood inside the line blackened by the oil being as clean and bright as when cut. The piles showed no indication of having been cut by the *teredo*.

Another suspension of creosoting occurred during the yellow fever epidemic of 1878. The work of construction was carried on during the winter following, and finished during the summer of 1879, by the rebuilding of the bridge across Bay Biloxi, one and one-fourth miles long, and across Bay St. Louis, two miles long. The deepest water here is about 15 feet, but the bottom is so soft as to require piles from 40 to 70 feet long.

Since then no organization for bridge work has been necessary on the road, as the bridges are in perfect line and surface.

The sandy country through which the road runs makes absolutely tight culverts or water-ways necessary. These have been built of creosoted timber and placed in the bank so as to allow a covering of earth of from one to twenty feet deep. Where the earth was solid enough these were constructed by using plank or timbers set edgewise, and running across the road bed. They were floored by plank extending into the bank outside the culvert walls about a foot, and covered by plank with a thickness corresponding to the width of opening. The openings vary from 1 to 12 feet in width, and from 1 to 6 feet high. They have one or more openings to suit the volume of water to be discharged.

Where the ground was soft piles were driven and capped and floored over, and the sides built of double sheet piling plank 1 inch thick, and driven to a depth to guard against washing out. For larger streams, from 50 to 600 feet wide, and the track, from 10 to 30 feet high, piles were driven, capped and floored over and covered with sand or gravel about a foot in depth, and in this was laid the ordinary embankment cross-ties to be lined and surfaced by the track men. This makes a cheap (and we think durable) viaduct, and does away with the jump or bouncing motion so often felt in passing open water ways or trestles, and protects from fire. I do not think creosoted timber half as liable to take fire as timber in the natural state.

Since then a wharf has been built at Ship Island, a foundation put under the lighthouse at Horn Island, and several pieces of work put in on the Mobile and Montgomery Railroad, and a wharf at the Mobile Depot.

Wharves have been built extensively in the Bay of Pensacola, and railroad bridges on the Pensacola and Atlantic Railroad.

Several thousand creosoted piles are in the waters of Pensacola Bay, where the *teredo* is very destructive to timber.

We have used a larger amount of oil per cubic foot of timber treated than has generally been considered necessary, but the almost universally satisfactory results confirm us in the opinion that creosoting is valuable in proportion to the amount of oil injected, and wherever a piece of timber decays or is destroyed by marine animals, it may be set down as a fact that there has been improper treatment.

The most carefully conducted experiments indicate that there is no decay without fermentation, and no fermentation without germs. If a piece of timber be cut green and thoroughly coated with paint, it will soon be destroyed by what is called dry rot. If a similar piece be heated through to 225° F., and a sufficient amount of oil be forced in to form an impervious coating, no decay will take place until that coating is broken.

Wherever that coating is broken, and the air with its dust allowed to come in contact with the unsaturated wood, decay follows and extends in each direction from the opening. It does not affect the whole mass of untreated timber at once, but commences at the opening and extends gradually, and it may be years in consuming all of the uncreosoted wood. If absolutely necessary to cut the timber after creosoting, such surfaces should be thoroughly oiled and pitched, or in some other manner protected. I do not think the "coagulation of the albumen" much of a factor in the preservation of wood. Something else must be relied on as an antiseptic. The character of wood seems to be so changed by saturation with creosote oil that the ferment germs find no nourishment, and though the oil may have become as thoroughly dried out as possible, no fermentation or decay takes place.

By the courtesy of the General Manager of the Old Colony Railroad, I have just been enabled to examine the bridge built over the Taunton River, at Somerset, in 1865. It was referred to by Chief-Engineer Winslow in 1878. Nearly all the original 700 piles creosoted have disappeared or have had another driven alongside, and are still left bolted in the bridge. Evidently the work was done in what we should now call a very superficial manner. The original "Bethell process" was used, depending solely on pressure to force in the oil, and with no provision for extracting the sap, except the traditional vacuum pump. Water cannot be drawn out of timber by simply producing a vacuum in the tank containing it. It is not forced in by atmospheric pressure, but by capillary attraction, which remains the same after the air has been exhausted. Neither can it be removed by ordinary steaming, as that only carries more moisture to the wood. The piles were green, and generally treated with the bark on. In creosoting, the greater part of the oil is absorbed through the side of the timber, and not by flowing along the pores. The bark, being spongy, absorbed more oil than the green wood, and acting as a strainer, retained the densest and best part of it. When, therefore, the bark fell off, which it was sure to do, the piles were left poorly protected. That part of the pile which received oil twenty years ago is as sound as when cut, though the interior may be rotten. The piles apparently have lasted much longer than they would had they not been creosoted.

A few piles were used around the draw-bridge that were not creosoted. The bark was relied upon for protection, and in places where the bark was off or where trimming was done, nails were driven in near together, and, I think, a cloth or something of that kind was laid on the wood, though I could not ascertain positively. At any rate, all such places that I saw, which had been below the water line, were sound and free from attack by the teredo. Some such patches were left above the water, the piles probably not being driven as far as anticipated, and in these the nails had completely oxidized, so that they could be dug out like sand, and the wood between the nails, which were about half an inch apart, was also destroyed, being as brittle and easily dug out as charcoal, while the surface of the wood around these places and out of the influence of the iron was quite good. The difference of the effect of the nails above and below the water line was plainly seen.

Some hemlock cross-ties were creosoted and laid in the track near the creosote works about sixteen years ago. They had been hewn and were more or less seasoned, and received a goodly quantity of oil. The oil has become dry and hard on the outside, but inside it is yet limpid and may be squeezed out, after removing the outside of the tie. I could not learn as a single tie had been removed for cause, and they with others of later date are doing service. Some other pieces of hemlock and spruce were creosoted and cut up for other use. Wherever the oil

penetrated, the timber is perfectly sound, though the center may be soft and rotten. The creosoted part is as tough and fibrous as ever.

I do not think the fiber of timber is ever made short or brittle by creosote, though it may be, and sometimes is, by overheating. I do not think timber should be heated to more than 250° F.

It has generally been considered that palmetto or cabbage wood was safe from the attacks of marine animals. I found several pieces at Pensacola, three or four years ago, which had been more or less eaten. This summer I saw at Charleston, South Carolina, numerous pieces badly eaten. They were taken out of a wharf, at the Custom House, which was being rebuilt. I sent samples to the rooms of the Society at New York. In some of the pieces the teredo seemed to be well fed and flourishing, measuring about half an inch in diameter.

With ordinary timber the bark is a protection against the teredo, but with the palmetto that seemed to be the choicest part, though they cut both wood and bark. The wood of palmetto seems to be a bundle of interlaced fibers, held in place by a kind of vegetable cement, which dissolves when the timber is used under water, and the fibers can then be drawn out singly. It has but little strength in either direction. Its greatest strength is in the bark.

Respectfully yours,

J. W. Putnam.

APPENDIX No. 14.

Remarks on Creosoting.

Octave Chanute, Esq.,

Chairman of the Committee on Wood Preservation.

Dear Sir,—My own practical experience in wood preservation has been confined to creosoting. In England, where the metallic salt processes, *i. e.*, Kyanizing, Burnettizing, etc., started in the race with creosoting about the year 1838, creosoting alone survives, and has been generally adopted wherever wood is used in railroad construction or other out of door work. Before engaging in creosoting as a business, I satisfied myself, through European correspondence mainly, that properly creosoted wood is indestructible by marine animal life, and will resist decay almost indefinitely. The members of our Society were at that time generally unfamiliar with the process and inclined to be skeptics. Since then sufficient has been learned from actual experience in this country to confirm the good reputation of this process in Europe.

In some of our earlier transactions are papers giving results of experiments in so-called creosoting, especially as regards its efficiency in preserving timber from the *teredo.** The fact is that it was not creosoting

* Trans. Am. Soc. C. E., Vol. III, paper No. XCV; No. CXXXI, Vol VI, page 189.

at all, but a pretense. Mr. C. B. Sears says: "Over 1 000 000 of feet was treated by the 'Robbins' process, a modification of the Bethell; it was impregnated * * * * with the vapor of hydro-carbon oil, about 1¾ lbs. of oil to the cubic foot, and cost $10 coin per 1 000 feet, b. m." This in California.

That such creosoting failed is no wonder, yet it served to prejudice the process.

The first really valuable information on wood preservation in the possession of the Society is the paper of the Secretary, John Bogart (on Permanent Way; Trans. A. S. C. E., Vol. VIII, January, 1879). This paper gives, in tabular form, without comment, categorical answers to a series of questions, asking for actual experience, obtained from an extended correspondence with the chief engineers of all the large railways in Great Britain. From that date the subject of wood preservation has been frequently discussed at our annual meetings, and several valuable papers thereon have appeared in our Transactions.

As stated above, the early creosoting was very imperfectly done, and generally by companies started with large paper capital for the purpose of selling stock. Creosote was expensive, and the methods adopted by these companies were efforts to dispense with the use of creosote, except in a vaporous state. In two or three places works were erected to carry out the Robbins vapor process, but there was little business and less faith. This failing, an attempt was made to adapt the weak machinery to good (?) creosoting. The cylinder burst at a pressure of 10 lbs. These attempts were followed by a period of distrust, and later came the creosoting of the present day, with expensive, powerful and efficient machinery, and a system of thorough treatment, which, in some respects, is superior to the English system, and will give good results.

There are three essentials to success:

1st. The selection of suitable varieties of timber.

2d. Proper dessication.

3d. The injection of a sufficient quantity of creosote.

First.—It is safe to say that the varieties of timber which are the most perishable without treatment are best suited for creosoting. They are absorptive; without treatment they readily take in from their surroundings the seeds of decay, and under treatment they absorb the creosote freely and evenly. Where such wood will be subjected to strains, the engineer must call for larger dimensions than he would use with denser and stronger woods. But such allowances made, the Virginia or North Carolina pine is far better for creosoting than the Georgia pine, and porous black or red oak than white oak, and in either case the more sap wood the better, as the sap wood is always fully saturated. Spruce is unreliable for the purpose, on account of the diversity in density in different specimens. The most conscientious treatment of spruce will fail to obtain uniform and reliable results.

Second.—Dessication.—The Bethell process in use in England requires that all timber intended to be creosoted shall be exposed in the air until fully seasoned. In this country, when any important contract requiring timber is awarded, the trees are still standing in the forests. There is no available seasoned timber. Hence we are compelled to adopt artificial dessication, with the aid of steam coils within the treating cylinder, before the creosote is admitted. But, through this necessity in the American process, we secure additional preservation, because the degree of heat employed in the dessication (about 250° Fahrenheit) coagulates the albumenoids in the sap wood, and thus, in so far as coagulation acts as a preservative, all which is accomplished by the metallic salt process is attained in addition to the action of the antiseptic and other properties of the creosote itself. Without preliminary dessication, creosoting must always be disappointing in its results, as there will be many wet places unprotected.

Third.—The injection of a sufficient quantity of oil. Creosoting does not claim to be a cheap process. Its cost, and that alone, stands in the way of its general adoption. On this account, while I protest against the small doses first used in this country (from an ounce of tar vapor to 2 lbs. of oil), I yet believe that more than enough is wasteful. During the first thirty years after the introduction of the process in England the practice was to inject from 6 to 8½ lbs. per cubic foot, and the longest records of sound usefulness are of specimens thus treated; but when the wood was to be protected from the *teredo* 10 lbs. per cubic foot were used. Eleven hundred piles driven at Leith, Scotland, in 1848, and reported by the engineer in charge as perfectly sound in 1882, were treated with 10 lbs. only per cubic foot. Later practice in England sometimes calls for 10 lbs. as a protection from decay alone, and Mr. Boulton, of London, who has had more than thirty years of practical experience in creosoting, wrote me that more than 12 lbs. per cubic foot is never called for by English engineers when for use in tropical climates.

It does seem to me that the dose proved to be sufficient in England should suffice here. The atmospheric conditions are quite as favorable to decay there, and the cutting tools of the *teredo* are quite as actively employed, the Gulf Stream maintaining a long season for their work. As a practical creosoter, while willing and able to inject from 20 to 40 lbs. per cubic foot in porous wood, if required, I feel impelled, in the interest of economy, to discourage the specification of more than 10 to 12 lbs. per cubic foot in most cases.

Creosote oil is a distillate of coal tar—a residual product in the manufacture of coal gas. Chemists have procured from coal tar a vast number of sub-products and combinations of great usefulness in dyeing, etc. The three principal coarse products of coal tar are the light oils, the heavy oils and pitch, all the results of distillation.

The light oils (lighter than water) evolve in the distillation at a tem-

perature of 360° to 480° Fahrenheit. From these all the aniline colors are made. They are expensive and have no value whatever in wood-preservation. The heavy oils (heavier than water) are distilled at a temperature of from 480° to 760° Fahrenheit. These are the so-called creosote oils, and contain all the constituents of the coal tar useful in wood preservation. After the creosote comes the pitch. Creosote contains about 5 per cent. of tar acids, *i. e.*, carbolic, cresylic and other acids, but the bulk is made up of semi-solid oils and naphthaline.

Wood preservation by the metallic salt processes is solely chemical. Earlier, it was claimed that the zinc chloride, etc., formed insoluble chemical combinations with the albumen contained in the sap wood. Now, it is generally allowed that no such combinations are formed, but that the value of metallic salts as antiseptics depends upon their continual presence in the woods, and as they are readily dissolved out of the wood their effect is only temporary. The life of wood is prolonged by their use, when skillfully applied, yet in moist places they quickly lose their efficacy.

The creosoting process is both chemical and mechanical. Besides the carbolic and other acids, it contains many other well-recognized antiseptic constituents; but it is probable that the very long life of timber secured by thorough creosoting is due far more to the fact that the pores of the wood are filled up with the thick, gummy, insoluble oils and the naphthaline, and thus keep out air and water, which contain the germs of decay. That such is the case was conclusively shown by M. Roltier,* a Belgian chemist, and later in 1866 by M. Charles Coisne,† Chief of Section of the State Railways of Belgium and Superintendent of the Creosoting Works.

By the latter, two series of experiments were tried during a period of five or six years in burying in a compost heap made of decaying wood, manure, etc., shavings impregnated with creosotes containing different percentages of carbolic acid. The results showed that shavings saturated with carbolic alone were entirely decayed, and those saturated with the distillates at the highest temperatures which contained no carbolic whatever were perfectly sound.

Experience with the metallic salts and the results of above experiments indicate that to preserve timber something more is required than an antiseptic for the purpose of coagulating the albumen. The very small percentage of albumen contained in the sap wood probably ferments readily and may originate decay; but the agencies of fermentation introduced into exposed timber by the air and water absorbed by the wood are vastly more dangerous than the seeds of decay contained originally in the wood itself.

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* Bulletin de l'Academie Royale de Belgique. 2me Series, Tome XVII. No. 4.

† Extrait des Annales des travaux publiques de Belgique. Tome XXII. Note sur la Construction des bois aux Moyens d'echantillons d'huiles creosotees obtenus a differentes temperatures. Ditto, Tome XXX.

During the past hundred years almost every imaginable substance has been proposed as a preservative of wood, yet it may be that inventors are still at work; if so, their attention would be best directed to such methods or materials as would close the pores of wood to air and water.

The following record of experiments made in the Harbor of New York by the Department of Docks of that city and kindly furnished by Mr. G. S. Greene, Jr., M. Am. Soc. C. E., Engineer-in-Chief of the Department, will probably prove of general interest.

EDWARD R. ANDREWS.

NEW YORK, May 10th, 1882.

DEPARTMENT OF DOCKS,
117 and 119 Duane Street.

ENGINEER'S OFFICE, CHAMBERS STREET,
Sept. 13th, 1883.

Mr. GEO. S. GREENE, Jr.,
Engineer-in-Chief.

SIR,—The accompanying comparative table gives the results of five annual examinations,* made by the aid of a diver, of certain pieces of wood put down in May, 1878, at the end of Pier No. 1, North River, to ascertain the effect upon them of the teredo. These pieces of wood have always been placed where the current is strongest and entirely clear of the mud line, in order to expose them to the full action of the worms, and to show as strongly as possible the value of the different means that were adopted to protect them.

The numbers and groups were as follows :

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* At each examination a cross-section about 2 inches thick was cut off of one end of each piece of wood.

ALL SPECIMENS WERE IMMERSED UNDER SAME CONDITIONS, MAY, 1878.

Groups.	No in Group.	Kind of Wood and Treatment.	Size of Specimen.	Condition of Specimens when Examined. May, 1879.	May, 1880.	May, 1881.	May, 1882.	May, 1883.
No 1	1	Spruce, no nails	4" × 10" × 12"	Large number of worms.	More eaten than last year.	More eaten than last year.	More eaten than last year.	Honey-combed.
	2	Spruce, entire surface covered with carpet nails	4" × 10" × 12"	No worms	No worms	No worms	No worms	No worms.
	3	Spruce, entire surface covered with 3d. nails	4" × 10" × 12"	No worms	No worms	No worms	No worms	No worms.
No. 4	10	Oak piles, no nails	31" long. 10" dia. 11" dia.	Large number of worms.	Large increase.	Same as last year.	More eaten than last year.	Honey-combed.
	11	Oak pile, carpet nails, 35 lbs. driven about ¼" apart	31" long. 10" dia. 11" dia.	No worms	No worms	No worms	No worms	No worms.
No. 5	14	Pine pile, no nails	36" long. 11" dia. 12" dia.	30 to 40 worms.	50 to 60 worms.	Honey-combed.	Not as bad as last year.	About 180 worms.
	12	Pine pile, bellows nails, 20 lbs., carpet nails, 12 lbs., driven about ¼" apart	36" long. 11" dia. 12" dia.	No worms	No worms	No worms	No worms	No worms.
No. 6	15	Spruce pile, no nails	36" long. 13½" d. 14" d.	30 to 40 worms.	60 to 70 worms.	Honey-combed.	Honey-combed.	Honey-combed.
	13	Spruce pile, 20 lbs. 3d. nails, driven about ¼" apart, and a zinc cap on one side.	36" long. 13½" dia. 14" dia.	No worms	No worms	No worms	No worms	No worms.
No. 7	16	Spruce pile, 4 lbs. carpet nails	One worm	One worm	One worm	One worm	One worm	No worms.
	17	Spruce pile, 5 lbs. 3d. nails; nails in both No. 16 and No. 17, driven from ½" to ¾" apart	3 to 4 worms	9 to 10 worms.	About 17 worms	About 17 worms	About 17 worms	10 worms.

ALL SPECIMENS WERE IMMERSED UNDER SAME CONDITIONS, MAY, 1878.

Pairs.		* Kind of Wood and Treatment.	Size of Specimen.	Conditions of Specimens when Examined.				
				May, 1879.	May, 1880.	May, 1881.	May, 1882.	May, 1883.
No. 1	1	White pine, creosoted	2'.11" × 14" × 3"	No worms	No worms	2 worms	No worms	No worms.
	2	White pine, not creosoted	2'.11" × 14" × 3"	A few worms	Honey-combed.	Honey combed.	Honey-combed.	Honey-combed.
No. 2	1	Oak, creosoted	2'.3" × 9½" × 3"	No worms	No worms	No worms	No worms	No worms.
	2	Oak, not creosoted	2'.3" × 9½" × 3"	A few worms	Honey-combed.	Honey-combed.	Honey-combed.	Honey-combed.
No. 3	1	Yellow pine, creosoted	2'.2" × 10" × 3"	No worms	No worms	No worms	No worms	No worms.
	2	Yellow pine, not creosoted	2'.2" × 10" × 3"	7 worms	Honey-combed.	Honey-combed.	Honey-combed.	Honey-combed.
No. 4	1	Spruce, creosoted	2'.2" × 10" × 3"	No worms	No worms	No worms	No worms	No worms.
	2	Spruce, not creosoted	2'.2" × 10" × 3"	8 worms	A few more	Honey-combed.	Honey-combed.	Honey-combed.

* Groups Nos. 1, 2, 3 and 4 were furnished by Mr. Edward R. Andrews.

(Signed) W. W. Maclay,

Supt. of Section.

APPENDIX No. 15.

Creosoting on Houston and Texas Central Railway.

Houston and Texas Central Railway,
Division Engineer and Supt.'s Office,
Houston, April 7th, 1882.

To the Committee on Preservation of Timber,
Am. Soc. of Engrs., N. Y.

Gentlemen,—In answer to your communication of March 29th, on the subject of preserving timber, I would say that the Houston and Texas Central Railway Company has treated about 150 000 cross-ties and a small quantity of bridge and tank-frame timber with creosote, or "dead oil," in the last two years.

Sufficient time has not elapsed for the results to be ascertained on this special work, but enough is known of the effects of "creosote" in preserving similar timber in this climate for a period of eight years to give a good guaranty of success.

The timber used thus far for ties is the short-leaf "Texas pine," a porous and perishable wood, that, untreated, will not last more than two years on or in the ground, or exposed to the weather. It takes the oil freely when partially seasoned, and when entirely dry will readily take more than two gallons to the cubic foot. Our works consist of two cylinders 100 feet long, in which the timber is treated, calculated to stand a pressure of 150 pounds per square inch; a superheater, and vacuum and pressure pumps, with suitable steam power and pipe connections, and cisterns for conveying and holding the oil. The process, in brief, is, first, application of superheated steam, then withdrawal of the condensed steam and sap that may have come from the wood, and production of a vacuum by means of a vacuum pump, the temperature being maintained at the same time by dry heat from the steam pipes, and finally following with the oil at a temperature of about 160 degrees, and with such pressure as may be necessary to produce the desired results.

Our ties contain about 4¼ cubic feet, and we propose to use about 5 gallons of oil to the tie; the length of time necessary to do this depends on the condition of dryness of the ties when treated. When quite dry, very little steam is needed; in fact it might be dispensed with; 30 minutes of exposure to superheated steam and the same length of time with an oil pressure of 20 pounds are sufficient.

But if the timber is green, 4 hours use of the steam, and 4 hours of oil pressure of 100 pounds per square inch, may not accomplish the same result. In practice, the treatment is varied within above limits, according to the condition of the timber and ascertained results after treatment. Natural seasoning is much the best, and it is considered that the saving in fuel and cost of running the works, by reducing the time of treatment to a minimum, will more than compensate for the expense of cutting the

ties, say, four months in advance, which in this climate is enough to put them in good condition. An examination of a lot of ties taken out of a cylinder after treatment will show that, while the oil consumed will average, say, 1¼ gallons to the cubic foot of timber in the cylinder, some of the ties are entirely saturated, and others have received the oil only to a certain depth from the surface, leaving the heart in its natural condition; a want of uniformity to be explained only by differences in seasoning, and differences in the grain of the wood in different trees. The latter cause is a peculiarity which will probably be found incident to every variety of timber to a greater or less extent, when exposed to this test. It is not easy to secure uniformity of treatment, for, if the pressure is continued until all of the timber in the cylinder is saturated, there will be a consumption of from 7 to 9 gallons of oil to the tie, which is much more than it is deemed necessary or profitable to use in cross-ties. It is desirable to ascertain what depth of penetration of a preservative is necessary (less than complete saturation) to insure protection.

Concerning this we have the following experience: A lot of short-leaf pine ties were treated for this company and placed in the track in 1875. They were treated in double lengths and cut in two to be used; dimensions, 7" x 9", 9 feet long. About 10 per cent. were not treated through, and an area of from 2 to 4 inches in diameter of natural wood was thus exposed at one end to air and moisture. These ties are now all perfectly sound where the wood received the oil, but decay commenced very soon at the untreated exposed ends, and has penetrated in at that end only to an extent varying in length in proportion to the size of the area exposed. Where the surface was 4 inches in diameter the hollow extends 30 inches; where only one inch in diameter the decay reaches 11 inches.

It is fair to infer that if these ties had been treated in the same manner in single lengths there would have been no decay, and the untreated parts would now be sound.

The timber has been hardened by this process, and shows as yet no serious wear. It would have been utterly worthless in two years had it not been treated.

Failures in the use of preservatives are most probably often in consequence of failure to secure the presence of the material in the wood, as it is only by frequent and careful tests while the work is going on that one can know the character of it, and that it is being well done.

Should you desire any further information in regard to our methods of treating timber, I shall be pleased to furnish it, as far as I can. The above is an outline only, and I have suggested some points for your consideration, which I think are worthy of investigation. I will send you a treated block of the pine timber we are using.

Yours respectfully,

M. G. Howe.

APPENDIX No. 16.

The Boucherie Process in Europe.

Paris, April 10th, 1882.

W. W. Evans, Esq.,

Consulting Engineer.—Sans Souci.

Dear Sir,—You ask for pamphlets concerning Dr. Boucherie's process of preserving wood. Some twenty years ago I was much interested in this question and investigated the matter. I was led by the study of the various systems to propose a combination of the Boucherie and the so-called Bethell systems. I published a pamphlet on the subject in French and German. I send you both by this mail; but it will not be easy to find the very "antique" *brochure* of Dr. Boucherie.

I will try to give you, however, some particulars on the history of Dr. Boucherie's processes.

Dr. Boucherie's first experiments were made in 1838. He introduced by aspiration (vital suction) in the trees an antiseptic (pyrolignite of iron). He changed his views, and in 1846 he preferred to introduce the antiseptic by hydraulic pressure and to use sulphate of copper (SO_3 CuO). During the year 1839 a communication on Dr. Boucherie's process was submitted to the Academy of Science, at Paris, but till 1846 no practical application was made.

In 1850 appeared in the Annales des Ponts et Chaussées (March and April, 1850), a report on Dr. Boucherie's process.

This report says that a trial of 7 years had given very good results. In 1846 the French *chemin de fer du nord* ordered 60 000 cross-ties of oak, preserved by Dr. Boucherie's process. At this time the cost of preparing a cross-tie was very high. A cross-tie of 0.10 cubic meters in volume cost 1 franc 11.4 centimes, as follows:

	Francs.	Cents.
General expenses	0.060	1.2
Building benches	0.048	1.
Transportation of ties	0.304	6.
Sulphate of copper	0.499	10.
Workmanship	0.203	4.
Total	1.114	22.2

He used nearly 7 kilogrammes of sulphate of copper per cross-tie, of which 5 or 6 kilogrammes were absorbed, the remainder being lost.

The Austrian Railroad, to which I was attached from 1860 to 1864, used Dr. Boucherie's process to preserve white beech ties, and I had charge of this department. In a tank, about 7 meters to 10 meters high, was the solution of sulphate of copper. Pieces of round wood of the double length of the ties were partly cut in the middle and the solution

introduced in the so formed space. The wood was fresh cut, and the solution ran through in longitudinal direction.

After 10 hours' treatment the wood was considered to be prepared. The surplus solution was received in gutters and pumped back into the tank. I found that wood containing too much sulphate of copper was brittle, and perished sooner than wood containing less of this salt. I explain this by the formation of crystals which burst the fine capillary spaces in the wood. I obtained the best results by washing out the excess of sulphate of copper. The combinations of oxide of copper with albumen and resin are not soluble in water. From 1867 to 1869 I tried to preserve wood in the harbor of Trieste against the *teredo navalis* by sulphate of copper. The first 12 or 15 months this succeeded, but when all the soluble salts of copper became washed out, the sea worm could eat the wood without danger to his health, and then the wood was no longer preserved against attack. To preserve wood against the *teredo navalis* or other sea worms by sulphate of copper it must be richly impregnated, so to conserve the soluble salts, and then be covered with tar, in order to prevent the copper from washing out of it.

The great trouble with Dr. Boucherie's process is that, to employ it, wood must be freshly cut, and that it has then to be sawed into cross-ties after preparation. The first condition gives trouble in the forest, the latter increases the cost. (The steel of the saws suffers much from the copper salts.) The outer parts of the wood are not penetrated by the antiseptic salt.

I developed all this in my pamphlet. When in 1870 I had to organize the preservation of cross-ties (white beech) on another Austrian railroad, I used copper cylinders in which I prepared cut cross-ties under 7 to 8 atmospheres pressure, after an introduction of steam in order to soften the surface of the dry cross-ties. This apparatus is still working, and has prepared about 2 000 000 of ties. The price of preparation is about 35 centimes. If creosote is cheap, I consider this antiseptic as the best. To fasten the rails on cross-ties prepared with copper salts, it is recommended that we make use of galvanized nails, or make holes for the nails and introduce tar in these holes as well as on the top of the ties where the rail touches them. In Germany they use preferably chloride of zinc for preserving cross-ties.

In France as well as in other parts of Europe the Boucherie process is nearly abandoned for the reasons above stated. When I used it in the years 1860 to 1864, in South Hungary, the cost of preparing a cross-tie under Dr. Boucherie's patent was materially lower than the 1 franc 11 centimes (22 cents) estimated in 1850. I believe it could be used for about 70 or 80 centimes (14 to 16 cents) apiece.

I am, dear sir,

Very sincerely and truly yours,

E. Pontzen.

APPENDIX No. 17.

Report on Economy of Burnettizing.

New York, Lake Erie and Western Railroad Co.,
Office of the Chief Engineer,
P. O. Box 839. New York, May 4th, 1883.

R. Harris, Esq., *Vice-President, &c.*

Dear Sir,—In answer to your inquiry as to what is my estimate of the annual saving to be expected, if Burnettized hemlock ties are used instead of the present practice, I beg to report that the following table shows the number of ties annually used in repairs.

Year.	Eastern Div.	Delaware Div.	Susquehanna Div.	Western Div.	Buffalo and Rochester Div.	Totals.
1875	186 700	140 597	118 045	102 375	92 000	639 717
1876	184 110	92 930	125 945	139 426	175 555	717 966
1877	148 201	107 354	123 576	110 141	108 466	597 738
1878	112 342	104 472	153 622	106 537	129 581	606 654
1879	155 000	238 000	215 500	121 130	232 213	961 863
1880	159 799	109 954	138 204	114 645	281 124	803 726
1881	132 300	126 958	118 204	117 419	155 422	650 303
1882	170 218	132 815	61 923	87 923	266 636	719 530
	Total..	....	....	....	....	5,697 498

These renewals, for the eight years tabulated, average 712 187 ties a year, and as during that time the road was operating an average of 1 329 miles of main tracks, and of 406 miles of side tracks, there were during that time approximately 3 520 000 ties in the main track and some 1 060 000 ties in sidings, a total of 4 680 000 ties on the whole line. This, divided by the 712,187 which were replaced on an average each year, gives an average life of 6½ years each for the unprepared ties heretofore used on the road.

I believe, however, that in point of fact the average life of ties is about 5½ or 5¾ years in the main tracks, and about 8 years in side tracks, where they are allowed to remain until they are in a worse condition of decay, and where the lesser running of trains diminishes their cutting under the base of the rails.

These ties are of three kinds of timber: white oak, which costs an average of 62 cents a tie, and lasts about 7 years; chestnut, which costs an average of 45 cents a tie, and lasts about 5 years; and hemlock, which costs an average of 28 cents a tie, and lasts about 3½ years. To the above prices must be added some 15 cents a tie, for the cost of distributing them, and putting them in the track, so that the first cost to the road, and the annual charges are as follows:

White oak,	cost	77c.,	lasts	7	years,	annual	charge	11 cents.
Chestnut,	"	60c.,	"	5	"	"	"	12 "
Hemlock,	"	43c.,	"	3½	"	"	"	12.3 "

All experience conclusively proves that hemlock ties thoroughly Burnettized will outlast unprepared white oak. On the German railroads, the returns of several lines show that Burnettized fir (this being the timber which corresponds to our hemlock) endures in the track from 14 to 15 years. A similar result has been obtained in this country on the Lehigh and Susquehanna Railroad, on the Vermont Central Railroad, and on the Chicago, Rock Island and Pacific Railroad, as well as experimentally on the Erie Railway; and such failures as have occurred can be directly traced to improper treatment, such as attempts to impregnate wood while yet full of green sap, or the use of too strong a solution, which tends to make the wood brittle.

In order, however, to make sure that the estimates shall be eminently safe, I shall assume a life of but 12 years for Burnettized hemlock in the calculations which follow. I am convinced that better results will be attained if the work is well and skillfully done.

I estimate the cost of Burnettized hemlock ties in the track as follows:

First cost of unprepared ties..................	28 cents.
Hauling ¼ of output at 16 cents each..........	4 "
Burnettizing	25 "
*Distributing and putting in track............	15 "
Total.........................	72 cents.

* In 1874 Mr. Albert Fink took some pains to ascertain what the cost of replacing ties was, and found it to have been 20.7 cents per tie for labor and 4.7 cents per tie for hauling, a total of 25.4 cents per tie on 877 113 ties, put into the main stem of the Louisville and Nashville R. R., from Jan. 1st, 1855, to June 30th, 1874.

The annual charge, therefore, if they last 12 years, will be 6 cents a year a tie, in lieu of the 11 cents a year a tie which the unprepared white oak ties are estimated to cost; while the annual charges on chestnut and unprepared hemlock are still greater.

The economy, therefore, of Burnettized hemlock ties over unprepared white oak amounts to 5 cents a tie in first cost (77–72c.) and to 5 cents a year a tie upon the number in the track, so that if we suppose two roads of the present mileage of the "Erie"—*i.e.*, with 1 467 miles of main tracks and 517 miles of sidings, on which there are approximately some 5 000 000 of ties, the one laid with Burnettized hemlock would save over the other, if laid with unprepared white oak, $250 000 every twelve years in the first cost, and also $250 000 a year in the average annual charge for renewals of ties.

This economy, however, can only accrue as fast as the road is relaid with Burnettized ties. The works which it is proposed to erect will have a capacity of 300 000 ties a year, but to cover mishaps and detentions it will be safe to assume that only 250 000 ties will be annually prepared. The annual economy, therefore, will be a gradually increasing one, until the whole road is relaid with Burnettized ties. The first year the saving will be only the 5 cents difference in first cost, say $12 500 for 250 000 ties; the second year it will be $12 500 on that year's purchase, and $12 500 more on the annual charge for depreciation of the 250 000 ties put in during the previous year. The third year the saving will be $12 500 in first cost, and $25 000 in annual charges on the 500 000 ties Burnettized during the previous two years, and so on.

The following table shows how this annual economy increases:

1st	year, difference in first cost 250 000 ties at 5c.					$12 500
2d	"	first cost	$12 500,	annual charge	$12 500	25 000
3d	"	"	12 500,	" "	25 000	37 500
4th	"	"	12 500,	" "	37 500	50 000
5th	"	"	12 500,	" "	50 000	62 500
6th	"	"	12 500,	" "	62 500	75 000
7th	"	"	12 500,	" "	75 000	87 500
8th	"	"	12 500,	" "	87 500	100 000
9th	"	"	12 500,	" "	100 000	112 500
10th	"	"	12 500,	" "	112 500	125 000
11th	"	"	12 500,	" "	125 000	137 500
12th	"	"	12 500,	" "	137 500	150 000
13th	"	"	12 500,	" "	150 000	162 500
14th	"	"	12 500,	" "	162 500	175 000
15th	"	"	12 500,	" "	175 000	187 500
16th	"	"	12 500,	" "	187 500	200 000
17th	"	"	12 500,	" "	200 000	212 500
18th	"	"	12 500,	" "	212 500	225 000
19th	"	"	12 500,	" "	225 500	237 500
20th	"	"	12 500,	" "	237 500	250 000

After the twentieth year, when all the ties on the road have been replaced with Burnettized hemlock (and I may here remark that nearly as good results can be obtained with Burnettized beech), the full annual economy of $250 000 a year will obtain as compared with the present practice.

Nothing has here been said about interest on the sums saved, nor about the certainty that the price of the more durable timbers will rapidly advance in the near future. Such calculations are more or less fallacious, because the cost of interest varies, and because the cheaper woods also advance in price, but I am very clear that it will be good economy to avail of the heavy body of hemlock and beech recently opened up by the extension of the Bradford Branch, by relaying a portion of the road with ties of those woods, Burnettized, before the timber is cut up for other uses.

Respectfully,

O. Chanute,

Chief Engineer.

APPENDIX No. 18.

Economy of Creosoted Ties.

New York, April 26th, 1882.

Octave Chanute, Esq.,

Chairman of Committee on Wood Preservation, Am. Soc. C. E.

Dear Sir,—I inclose a calculation to show true economy in the use of preserved railway ties. This economy is not shown in the first cost, but in their longer life and in the relative annual cost per mile of track of preserved and unpreserved ties. I assume sixteen years as the probable service of creosoted soft wood ties, and eight years for unpreserved white oak ties. The former is the average life of creosoted Baltic fir sleepers on the railways in England, where the traffic is almost constant (see Bogart's paper, Trans. Am. Soc. C. E., Vol. VIII, page 18); the latter is all which is claimed for the best oak ties in this country, and they are generally dozy and unsafe during the last two years of their service.

As it is sometimes claimed that the sum representing the extra cost of preserving, if put at interest, would yield enough to replace unpreserved ties when rotten, I make the calculations at compound interest.

Example.—Relative cost per mile of track of white oak ties @ 80 cents each, and creosoted soft wood ties @ 90 cents* each, the quotations at the present time.

* As the price of creosote at the time of this publication is lower than in 1882, the price at which ties could be creosoted is less in proportion.

April 1st, 1882.	Cost of 2 600 creosoted soft wood ties, @ 90 cents each, for one mile of track...........................	....	$2 340.00
"	Compound interest at 6 per cent. for eight years....................	....	1 380.60
			$3 720.60
"	Cost of 2 600 best quality white oak ties, @ 80 cents................	$2 080.00	
	Compound interest for eight years...	1 233.44	3 313.44
April 1st, 1890.	Cost of 2 600 creosoted soft wood ties at the end of eight years' service, already in place, and good for eight years more......................	....	$407.16
"	Cost of 2 600 new white oak ties to replace those laid in 1882, @ 80 cents each	$2 080.00	
"	Cost of transportation and relaying, @ 15 cents each....................	390.00	
		$2 470.00	
"	Compound interest for eight years, @ 6 per cent. on $2 470.00..........	1 464.71	
"	Compound interest on cost of 2 600 creosoted ties, good for eight years, $407.16........................	....	241.44
April 1st, 1898.	Balance in favor of soft wood ties per mile of track during service of sixteen years......................	....	3 286.11
		$3 934.71	$3 934.71

Further, the annual cost for ties per mile of track laid with best white oak ties, @ 80 cents each, during a period of sixteen years, is.		$453.01
Ditto, of creosoted soft wood ties, @ 90 cents each, is.....	$241.31	
Balance in favor of creosoted soft wood ties per annum, during a period of sixteen years, is....................	211.70	
	$453.01	$453.01

That the life of creosoted soft wood ties in this country will probably be sixteen years seems evident from the experience on the Central New Jersey Railroad, which has had laid in its main line, and under very heavy traffic, 10 000 creosoted Virginia pine ties during the past six years, and, so far, they show no signs of cutting under the rail, and are perfectly sound and apparently good for ten years more service.

From the above figures it appears that the cost of the creosoted ties for the ninth year is $407.16 per mile, or about equal to the annual cost of white oak ties during the first term of eight years, *i. e.*; $414.18. Hence, if under the heavy rolling stock at present in use the creosoted soft wood ties will not last sixteen years, they will effect a saving of $414.18 per mile of track for each and every year of service beyond nine years.

A service of sixteen years is allowed for trunk roads with very heavy traffic, but on roads with smaller business and with less wear on the ties, if absorbent woods be used, so that the treatment of the ties can be thoroughly done, it is safe to claim for creosoted ties a service of twenty-four years. (The English ties belonging to the Society are perfectly sound after twenty and twenty-two years wear, even on the London and Northeastern and the Southwestern Railways, where they were subjected to the whole immense traffic of those roads.) On a lower estimate for white oak ties, say 60 cents each, and an assumed life for creosoted soft wood ties of twenty-four years and costing 90 cents each, the annual cost of white oak ties lasting eight years, requiring two renewals, with an additional charge of 15 cents per tie for expense of transportation and relaying at each renewal would be...................... $227.50

While that of creosoted soft wood ties would be only.......... 97.50

An annual saving per mile of track of................. $130.00

I realize that the above figures and considerations will not be applicable in every case, but I hope they may serve to induce engineers to give a careful consideration to one of the most effective means of reducing the expenses of railway road-beds.

Yours truly,

EDWARD R. ANDREWS,
Assoc. Am. Soc. C. E.

APPENDIX No. 19.

Economy of Preserving Timber.

By B. M. Harrod, M. Am. Soc. C. E.

The discussion of the methods and results of preserving timber leads to the question of relative economy, and when they can be profitably used. To make this clear, a statement has been prepared with regard to two of the most important uses of timber, viz., cross-ties and bridges, showing what increase of life or duration, under processes of different cost, is necessary to justify their use, by economic considerations. The prices and duration assumed are intended to be a fair average of those prevailing throughout the country. The method of computation can, of course, be applied to figures altered to suit different localities and circumstances.

If unpreserved ties cost 40 cents to deliver, and 15 cents to lay, spike and tamp, 2 600 can be laid to the mile at a cost of $1 430. Assuming five years as the average life of such ties, 520 of them must be renewed annually.

Each one will cost, in place, say 65 cents, or 10 cents more for relaying than for the first laying, amounting to $338, annually, per mile. This sum, capitalized at 6 per cent., is $5 633.33. Now, the original cost of ties, plus a capital whose interest will maintain them, can be fairly considered a fixed sum, from which the relative economy and required life of preserved ties can be deduced. This, as estimated above ($1 430 + $5 633.33), is $7 063.33 per mile.

Now, assuming that a tie costing 40 cents can be carried to and from the preserving works for 5 cents, and preserved for 20 cents, and laid for 15 cents (total 80 cents), we have $2 080 as the first cost of 2 600 ties in a mile. This, deducted from the fixed sum, leaves $4 983.33, capitalized, for maintenance, producing $299 per annum at 6 per cent. With a renewed tie costing 40 cents, preservation 20 cents, extra transportation 5 cents, and relaying 25 cents (total 90 cents), the interest on the balance for maintenance ($299) is only sufficient for 332.22 new ties per mile, or 1 in each 7.83, annually. It is therefore necessary, in order to justify a cost of preservation of 20 cents per tie (or of 25 cents, transportation included), that the average life of each should be 7.83 instead of 5 years, or an increase of two years and ten months.

In like manner we find that a cost of preservation of 40 cents per tie must insure an average life of 10.68 years; a cost of 60 cents a life of 14.29 years; a cost of 80 cents a life of 18.99 years, and a cost of $1 a life of 25.37 years. Also, that an indestructible tie is worth, in place, $2.72.

These results can be checked in a table, as follows:

First Cost.	Interest.		Annual Renewals.	6 per cent. on $7 063.33.
($1 430 at 6 per cent.	= $85 80)	+ ($\frac{2\ 600}{5}$	= 520.00 at .65 = $338.00)	= $423.80
(2 080 " "	= 124.80)	+ ($\frac{2\ 600}{7.83}$	= 332.22 " .90 = 298.80)	= 423.80
(2 600 " "	= 156.00)	+ ($\frac{2\ 600}{10.68}$	= 243.45 " $1.10 = 267.80)	= 423.80
(3 120 " "	= 187.20)	+ ($\frac{2\ 600}{14.29}$	= 182.00 " 1.30 = 236.60)	= 423.80
(3 640 " "	= 218.40)	+ ($\frac{2\ 600}{18.99}$	= 136.93 " 1.50 = 205.40)	= 423.80
(4 160 " "	= 249.60)	+ ($\frac{2\ 600}{25.37}$	= 102.47 " 1.70 = 174.20)	= 423.80

If we assume the cost of bridge timber at $15 per thousand, its framing at $15, and its average life at seven years, we find, by applying a similar computation to 100 000 feet, that a cost of preservation of $5 per thousand requires a life of 8.8 years; a cost of $10 a life of 10.85 years; a cost of $15 a life of 13.3 years; a cost of $20 a life of 16.2 years, and finally, a cost of $25 a life of 19.7 years to justify its use.

The rigid application of such a statement as this would be modified by certain general considerations which are sufficiently obvious.

The more inferior the material, or the more exposed the situation, the greater is the relative importance of preservative processes. Five years additional life doubles the value of material which, unprepared, would only last five years, while it only adds 50 per cent. to the value of material naturally good for ten years. Under this consideration, the inferior pines, gums, and even cottonwood, might be used for ties.

Again, difficulty of access for inspection or repair is a good reason for preservation, even when its immediate economy is not apparent. This would apply to piles and bedded or concealed sleepers.

Also, the use of more enduring materials reduces the cost of maintenance of engineering constructions in various indirect ways that are difficult of estimate in a general statement. For instance, if cross-ties lasted twelve years, instead of five, five men could do the work of replacing over a length of road that now requires twelve men.

Under the present rate of consumption, such scarcity of raw material as will very greatly enhance its value is in the near future. There is a wise economy in limiting the use of our wood-land wealth to the rate at which it accumulates, as well as in preventing other well-attested evils that will surely follow the deforesting of the national domain.

It is therefore reasonable to claim that when the economy of preserved and of unpreserved lumber, based on relative cost and durability, appears evenly balanced, there are still reasons, perhaps remote, but certainly valid, why a preference should be given the former.

APPENDIX No. 20.

FORMULÆ FOR COMPUTING COMPARATIVE ECONOMY OF RAILROAD TIES.

By the late ASHBEL WELCH, Past President Am. Soc. C. E.

In finding the comparative economy of railroad ties of different prices and durabilities, we may either suppose that they will, on giving out, be replaced by the same kind in the future indefinitely, or we may confine our comparison to the ties used at the present time.

In the former case we find the present value of the sum of the advantages of an indefinite succession of one kind over another, in the latter case we find the present value of the advantage that a single tie of one kind has over another. The amount of advantage will therefore be greater in the former case than in the latter.

Let W be the cost, and let it also be assumed to be the true value of a white oak tie that will last in the track where it is to be placed the time T, including in the cost transportation, handling, use of storage room, interest between the time of payment and use, putting into the track and all other expenses.

And let a be the rate of accumulated compound interest for the time T.

Let c be the cost of some other kind of tie that will last in the same track the time T', including all expenses as above, and also any cost of treatment for preserving it, and any excess in handling, use of storage room and interest while being treated; and let a' be the rate of accumulated compound interest for the time T'.

Let us first suppose that whatever tie is adopted is to be replaced in perpetual succession by the same kind of tie, and that costs and durations remain constant.

Let L be the loss on renewal of the white oak tie, and L' of the other kind being the total cost of the tie laid in the track, including the same kind of charges as above, and taking out the old tie and putting in the new, the loss on spikes and injury to rails while making the change, and all interruptions and risks, and deducting the value, if any, of the old tie.

Also let V be the value of a tie that in the same track, all things remaining constant, would last forever, and let R be the real value for that track of the other kind of tie as compared with the unpreserved white oak tie.

Then the differences between c and R will be the advantage or disadvantage of the other kind of tie in comparison with the white oak.

The current charge against the white oak tie after renewal at the end of the term T is $a W + L$. Against an indestructible tie it would be $a V$. But in order that one shall be just as advantageous as the other, their current costs must be equal, so that $a V = a W + L$, and dividing by a we have

$$V = W + \frac{L}{a}.$$

In the same way we have $a'\ V = a'\ R + L'$ and $V = R + \frac{L'}{a'}$ and $R = V - \frac{L'}{a'}$ in order to make R, or what would be the cost of the other kind of tie, just as advantageous as the white oak.

Let $W = 0.80$, $T = 7$, $L = 0.80$, $c = 0.65$.
$T' = 5$ and $L' = 0.65$.
If interest is 7 per cent., $a = 0.62$ and $a' = 0.41$.

Then $V = 0.80 + \frac{0.80}{0.62} = 2.09$ and $R = V - \frac{L'}{a'} = 2.09 - \frac{0.65}{0.41} = 0.505$.

So that for perpetuation in that track, traffic and prices being constant, the tie (chestnut) that costs 65 cents is only worth 50½ cents.

Suppose $c = 0.45$, $T' = 3.5$, $L' = 0.45$, and $a' = 0.272$, the interest for 3½ years.

Then $R = V - \frac{L'}{a'} = 2.09 - \frac{0.45}{0.272} = 0.436$,

or within less than a cent and a half of the cost of the hemlock tie, *i. e.*, 45 cents.

If we compare the ties for their own lifetimes the differences will not be so great.

The economic depreciation of the white oak tie (which may differ widely from the physical depreciation) at the end of the time T' when its competitor gives out is $a'\ V - a'\ W$. This is equal in the case of the chestnut tie to $(0.41 \times 2.09) - (0.41 \times 0.80) = 0.53$ the present value of which is $\frac{0.53}{1 + 0.41} = 0.376$. Add to this the present value of accumulated interest for that time $= \frac{0.80 \times 0.41}{1.41} = 0.23$, and we have the true value of the chestnut tie $= 0.609$, or a little over four cents less than it costs.

The economic depreciation of the white oak tie in the lifetime of the hemlock tie, 3½ years, is $(0.272 \times 2.09) - (0.272 \times 0.80) = 0.35$; to which add accumulated interest for 3½ years, or say: $(0.80 \times 0.272) = 0.2176$, which makes 0.5676, the present value of which is $\frac{0.5676}{1 + 0.272} = 0.446$, this being the relative value of the hemlock tie, which is less than half a cent less than its cost.

If the white oak can be made to last 14 years by some treatment, it would be worth for perpetuation, supposing its renewal costs its present time value $R = V - \frac{R}{1.62}$; (1.62 being the accumulated interest for 14 years). Hence $2.62\ R = 1.62 \times 2.09$ and $R = 1.29$. So that it would pay to spend 49 cents on the white oak tie in order to double its lifetime.

The economic depreciation of one white oak tie or any other whose cost was its true value, for the lifetime of any other tie T' is $a'\ V - a'\ W$.

The accumulated interest on the cost of W up to the same time is $a' W$.

To get the present value of each of these we divide by $1 + a'$, the sum of the quotients being the real value of a tie that will last the time T'. But we may as well add the depreciation and interest together and divide the sum by $1 + a'$.

Thus $\frac{V a' - a' W + a' W}{1 + a'}$ is the result we want, but we see on inspection that this equation is equal to $\frac{V a'}{1 + a'}$ and get a simpler equation. Assuming the longer lived tie to cost its true value, then the true value of the shorter lived tie is $= \frac{a' V}{1 + a'}$.